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The Journal

OF THE

Royal United Service Institution.

Vol. VI. 1862. No. XXI.

Evening Meeting.

January 20th, 1862.

Major-General the Hon. JAMES LINDSAY, M.P., Chairman of the Council, in the Chair.

Names of Members who joined the Institution between the 1st and 20th of January, 1862.

Burn, J. M., Lieut. Royal Art. 1*l.*
Furlong, J. M. (M.D.), Surg. 42d High. 1*l.*
Armistead, Rev. C. J., M.A., Chaplain R.N. 1*l.*
Silk, G. C., Lieut. South Mid. Rif. Vol. 1*l.*
Dawson, R. N., Capt. Royal Engs. 1*l.*
Prichard, A., Capt. 28th H.M. Madras N.I. 1*l.*
Julian, T. A., Capt. 52nd Regt. 1*l.*
Rennie, J. (C. B.) Capt. H. M. Indian Navy, 1*l.*
Tupper, De Vic, Capt. 2d Bat. 8th King's, 1*l.*
Vyvyan, W.C., Ens. late 4th King's Own, 1*l.*
Stirling, W., Major Royal Art. 1*l.*

CHAIRMAN'S ADDRESS.

This being the first Evening Meeting of the year, I will, with your permission, before my gallant friend Captain Scott reads his paper, say a few words upon the position of the affairs of this Institution.

In the first place, I have much pleasure in announcing that between the period of our last meeting in this Theatre and the end of the year, 114 Members joined the Institution, making a total of 305 for the year 1861, whilst 11 have joined since the beginning of this year. This may perhaps appear a large number, but when it is considered that the whole of the officers in the navy, army, and other military services are eligible to become Members, it is not greater than what may reasonably be expected in the course of a single year. This Institution, perhaps more than any other, depends upon numbers for its support. From the circumstances and duties of the officers of the army and navy, the subscription must necessarily be small, and therefore the 305 new Members do not represent the same money value as they would in other institutions. The great object which the Council have in view is to make this Institution both interesting and useful to the Members who do not frequent the Metropolis, or who are serving abroad, as well as to those who are able to make personal use of its resources; and I think I am right in the obser-

vation, that perhaps no other Institution gives so much, at so small a cost, to its Members. The more our financial power is increased, the more worthy of the country, and the more valuable as a means of diffusing professional information, the Institution will become.

The Journal is doing good service for the Institution. We are much beholden to the gentlemen who have come forward in this Lecture Theatre to treat upon those professional subjects with which they are conversant, and who promulgate their opinions by means of the Journal to their brother-officers, stationed, as they are, in every part of the world.

The lectures which have been delivered in this Theatre, during the past year, have been for the most part upon that particular subject which my gallant friend on the left continues to-night. We have had no less than eleven papers read during the past season upon iron ships and the improved ordnance. Discussions followed upon most of those papers, conducted with very great ability by naval officers and by civil engineers. In this way it is evident science is improved, information is circulated, and the services, both army and navy, as well as the country at large, are greatly benefited.

The Journal is peculiarly appreciated by the officers serving in the Colonies, who are thus kept *au courant* with the progress of science and with the opinions of those whose time and abilities have been devoted to the study of inventions and improvements in the appliances of modern war. So much is this the case, that of the 305 new Members, no less than 102 who were stationed in India, the Cape, and other dependencies of the Crown, became Members in order that they might receive it. This is an undoubted recognition by the officers of both services of the professional value of the Journal, and we trust by degrees, as it is more and more appreciated, to find the officers on full pay recognising it in a substantial form by enrolling themselves as Members. In the mean time, the expense of printing, illustration, and publication, is very large, while its circulation to all parts of the world is conducted entirely free of expense to those Members who receive it.

The expenses of the staff, of the rent and taxation, of the ordinary business, of the publication and circulation of the Journal, and of the library, as yet absorb the greater part of the receipts. And, although the model departments have not been neglected, the Council hope, as the finances increase, to render them as complete, both in general interest and in utility, as may be worthy of a great professional metropolitan establishment.

Although this Institution has been in existence for upwards of thirty years, it is only recently that it has been able to carry into effect the original designs of its founders. In its earlier years, although its financial capacity was great and sufficient for the intended purposes, yet it laboured for a long time under the disadvantage of inadequate accommodation. By the time the Institution became possessed of all that was required to render itself prominent by its usefulness, its resources were exhausted; the original enthusiasm in its career had abated, the feeling in favour of professional knowledge was at that period at a low ebb, and the income had fallen to an extent which for some time prevented adequate use being made of the improved accommodation.

During the last few years, however, these difficulties have been over-

come. The finances of the Institution are in a vigorous condition, and are concentrated upon the advancement of professional information relating to the naval and military services. A general recognition of the necessity and value of professional studies and discussions has arisen among officers; and the Council has made full use of this opportunity by devoting the resources of the Institution to the advancement of this object. The efforts of the Council have been successful; the officers themselves have been the first to acknowledge their appreciation of all that has been done, and are gradually proving this by tendering their support. The Government have recorded their opinion by proposing a small annual grant to assist the Literary and Scientific Departments; and both the Admiralty and War Departments, when opportunities present themselves, show the favourable opinion they entertain.

When the Commissioners of the International Exhibition of 1862 decided to form a military class, they requested Lord Herbert to nominate a Committee. Lord Herbert at once referred the subject to the Council of this Institution, and requested them to undertake the duties—a distinct recognition of the high character which it held in the opinion of the Secretary of State. Both the Naval and Military Committees have held their sittings in the Council Room of the Institution.

I cannot avoid trespassing upon your time for a few moments upon a subject which has been brought home to the minds of every subject of Her Majesty, throughout the whole length and breadth of the land. I allude to the loss which the country, the army, and this Institution have sustained by the untimely death of the late Prince Consort. Her Majesty became a patron of the Institution shortly after she came to the Throne, and His Royal Highness became joint patron with the Queen in 1841. As soon as he became acquainted with the objects which the Institution was designed to promote, he became a warm supporter.

From the position which I have had the honour to hold for some years, as a commanding officer of a battalion and regiment of Guards of which the late Prince Consort was colonel, I had the privilege of frequently approaching his person, and I occasionally took the opportunity of speaking to him upon the merits of this Institution, when I had the honour to wait upon him. His Royal Highness always expressed himself warmly in its favour, and entered minutely into the position of its affairs, and, when its fortunes were in a low state, into the prospects of improvement. He fully comprehended the cause of prostration, and foresaw the means by which alone it could be restored. His advice was on all occasions most valuable. When we were endeavouring to get a grant from the Government in aid of the finances of the Institution, having failed in two or three instances to impress the Government with a sense of the importance of the objects we had in view, it may be inferred that the warm interest he took, may have indirectly influenced others to acknowledge that the Institution had as much claim to permanent support as other literary and scientific establishments.

Again, he was a great advocate for concentrating our efforts upon those objects which this Institution alone is endeavouring to promote. Formerly we had an Ethnological collection, and a Natural Historical collection. It was his opinion that these collections could never by any possibility be made useful to the officers of the two services. They were imperfect collections at the best, though there some good and valuable

things in them; and the other institutions devoted specially to those particular branches of science, of course, had much better collections.

Again, no later than a few months ago, the lease of these premises approaching its termination, I mentioned to His Royal Highness how necessary it was that we should remain in our present locality. Officers of the Army and Navy, having their clubs in Pall Mall, and occupied at the Admiralty and the Horse Guards, would naturally prefer coming to the Institution in Whitehall, than to have to go to Kensington, or some other remote locality, which, for reasons needless to detail at the present moment, would be ruin to our prospects. It is, therefore, an important object that we should remain here. His Royal Highness saw, as we did, the immense advantage to the Army and Navy of our present position, and the necessity of our continuing in it, and expressed a hope that circumstances would leave us undisturbed.

I cannot but express the feeling that in him we have lost a very sincere friend, and that his good offices would have been of very great assistance to us in maintaining our present position in Whitehall Yard. It was the duty of the Council, at their last meeting in the beginning of January, to prepare an address of condolence to her Majesty upon the irreparable loss which both she and the nation have sustained, and which, signed by the President of the Institution, has since been presented; I am sure the Members, when this is duly reported to them at the next annual meeting, will approve of the step which the Council has taken in performing a duty in common with the rest of the country.

I regret to add that some of our most distinguished Members have died since we last met—General Sir Howard Douglas, upon whose intellect and great abilities age seemed to have little effect, and who contributed within a short time previous to his death opinions upon the great subject of the day, War Ships and Rifled Ordnance, was one of the founders of the Institution, and was the Chairman when it was established. He was an officer of great scientific acquirements, and through a long life, whether in or out of employment, his mind was always actively employed in the service of his country.

Lord Herbert, as a War Secretary, was a warm supporter of this Institution. He saw the value of the policy pursued, and he always cordially entered into our objects and requirements. We have lost in him a friend, who, as far as opportunities permitted, was anxious to advance our interests.

Several distinguished officers have also been removed by death. Among them I cannot forbear mentioning the names of General Sir Charles Pasley, K.C.B., and Vice-Admiral Sir Richard Dundas, K.C.B.; the former was eminent as a military author and engineer, and rendered great services to the nation by his attention to the system of pontooning; the latter commanded the Baltic fleet in the Russian war and was one of the Lords of the Admiralty at the time of his death.

Having said these few words, I will now ask Captain Scott to read the paper which he has prepared. Captain Scott is an old friend of this Institution. He gave us a most valuable paper last year, which has been published in a recent number of the Journal. I am perfectly convinced that, with the abilities he has shown, and the attention he has paid to the subject, there is no paper he can read which will not be most warmly approved of.

THE PROGRESS OF ORDNANCE ABROAD COMPARED WITH THAT OF ORDNANCE AT HOME.

By Commander R. A. E. SCOTT, R. N.

I do not think I can commence this paper better than by quoting the words of the present distinguished Chief of the Admiralty, the Duke of Somerset,* respecting the value of this Institution, in which subjects that are not only professional, but such as are of deep interest to all Englishmen, can be discussed in the fair and open manner necessary to elicit truth. His Grace says:—

"I know in regard to the Navy a great many things are discovered, and are put aside for the want of a proper place to preserve them. Many years afterwards what are thought to be discoveries are made, and we often find, if we had looked back and consulted our papers, that the discoveries had been made a long time ago. That is continually occurring, and it shows of what great advantage an institution of this kind may be, in recording information of this character and communicating it throughout the Services.

"If you adopt as a matter of faith that So-and-so is quite right, and that whoever says to the contrary has a bad motive, and is a dishonest fellow, why, you may settle the question easily in your own mind, but you do not settle it to the interests of the country. What we have to do is to look at these questions calmly in all their bearings, and I am sure, if that were done, we should then arrive at a satisfactory result."

Yet there may still be doubts in the minds of some as to the advisability of speaking the whole truth. Let such persons learn from the wise example of the Emperor across the water in at once exposing the real state of the finances of France, and thus making friends of his people by admitting them to his confidence.

It is only in great minds, and amongst a great people, that there is a readiness to acknowledge error; little minds and a little people try rather to shuffle out of false positions than to frankly admit a mistake; and there may be some who, like the bird that tucks its head under its wing, refuse to see. Such persons would desire to shut out the truth; but of what advantage is it to hide our true position from our own people? "To be forewarned is to be forearmed," the proverb says, and any one who reads the French and other foreign works must know that continental nations narrowly watch our progress, and can estimate the full value of our changes far better than we do ourselves. We indeed have been too well satisfied, to properly consider and carefully weigh the effects of our alterations;

* Vide the Duke of Somerset's speech at the General Annual Meeting, on the 2nd March, 1861.

but, should war unfortunately take place, the present blind confidence in our armaments might be rudely dissipated, and untried weapons fail us at our utmost need.

Lately public attention has been much occupied with our naval armaments, and there is no subject of greater national importance; for on our maritime supremacy, our high position, nay, our very existence as a great people (humanly speaking), depends. There is therefore a necessity for thoroughly ventilating and settling the matter definitively. This will at once be evident, as well to the landsman present as to the seaman, when he is informed that, in a frigate of 51 guns, he may find, in consequence of our recent changes in ordnance, six different guns, and five different kinds of shot.

The naval artillerist is already too well aware of the disadvantages he will be placed under by such complications, and knows what must result from them when men's nerves are highly strung, comrades falling around, and smoke and splinters filling the decks; and, since there are in this Institution a large proportion of experienced officers both naval and military, I can confidently look for a patient hearing, and an unprejudiced decision upon the truth or error of my views.

In my former lectures, published in the nineteenth number of the Journal, I pointed out defects in the systems which at that moment were enjoying popularity in England, and I have since seen my statements fully confirmed. This evening I will endeavour to place before you what foreign nations are doing, and ask you to join me in contrasting their progress with our own, so as to see how far we have advanced relatively, if not absolutely.

Foreign Rifled Guns of Early Date.

It may cause surprise to hear how early rifled guns were used. In the Arsenal of St. Petersburg is a gun $2\frac{3}{4}$ inches in diameter, and 62 inches in length of bore, which was rifled in nine grooves in 1615. This gun is a breech-loader, and there are several wall-pieces and rifled muskets in the French and other museums, which were grooved about this date on plans that have been lately revived.

In 1661 the Prussians experimented at Berlin with a gun rifled in thirteen shallow grooves.

1694. Nuremburg had a gun forged and rifled, which was tested on several occasions.

1696. The elliptical bore was known, and had been tried in various parts of Germany.

1745. The date at which Robins was experimenting in England, the Swiss already possessed small rifled pieces.

1746. Munich had a rifled breech-loader made, and T. Senner was engaged in rifling various guns.

1816. Reichenbach rifled a bronze gun with seven grooves. This piece is still in possession of the family in Bavaria, and has been fired with pointed leaden balls.

1816 to 1819. M. Ponchara, a distinguished French artillery officer, was making various experiments with an old gun which he had rifled with thirteen grooves.

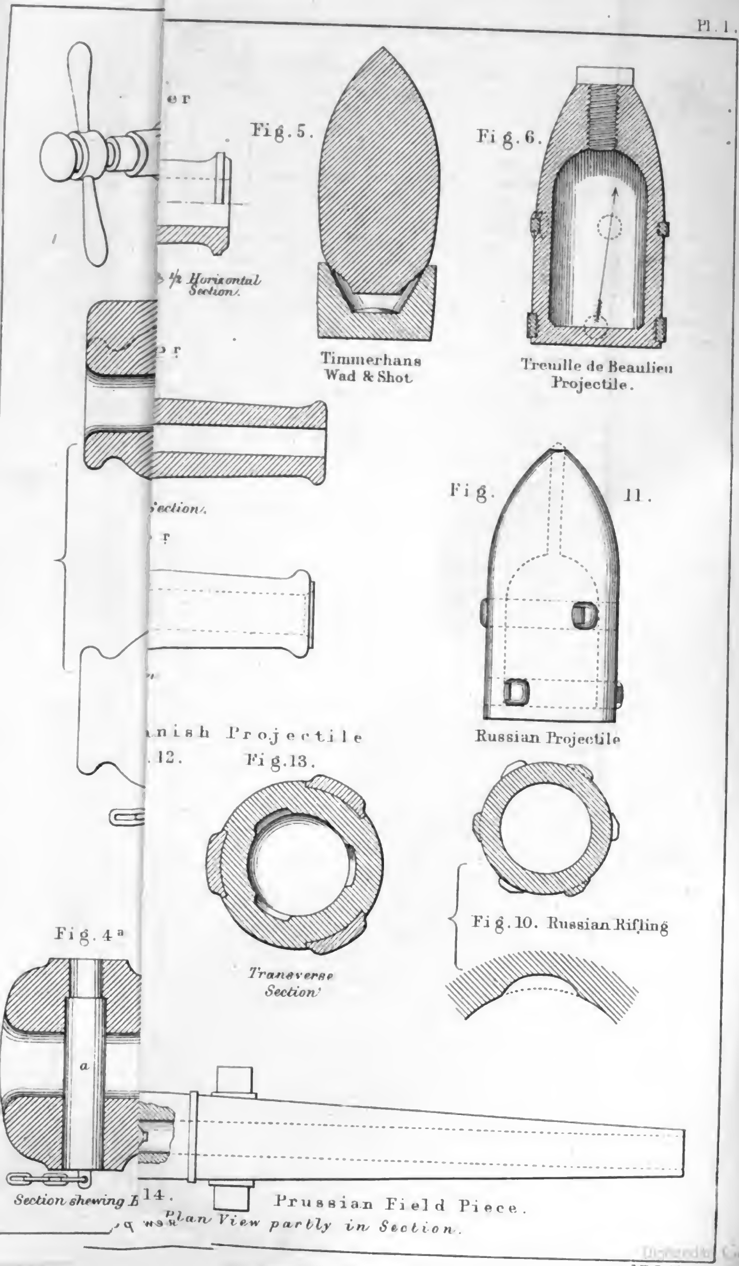


Fig. 5.
Timmerhans Wad & Shot
Fig. 6.
Treulle de Beaulieu Projectile.
½ Horizontal Section.
Section.
Fig. 11.
Russian Projectile
anish Projectile
.12.
Fig. 13.
Transverse Section
Fig. 10. Russian Rifling
Fig. 4a
a
Section shewing B
14.
Prussian Field Piece.
Plan View partly in Section.

J.R Jobbins.

1833. Montigny of Brussels invented a breech-loading rifled piece, and the Belgian government had a gun made on his plan. The arrangement of the breech apparatus was simplified in 1835.

1836. The late Emperor of Russia, Nicholas, sent for the inventor, and ordered breech-loading guns of 18 and 24-pound calibres to be made and rifled on Montigny's plan. 1,800 rounds had been previously completed in his presence from a 12-pounder. When these guns were prepared 262 shots were fired in one day from the 18-pounder, and 100 shots continuously on successive days from both the 18 and 24-pounders, and neither wad nor grease was used. But the commission presided over by General Samarakoff rejected the plan. (Plate I., fig. 1). After this, Montigny, the son of the former, went to England, but his applications for an extended trial were unsuccessful.

1845. Major Cavalli, a Sardinian officer, commenced his experiments on rifling, and these seem to have inspired Wahrendorf with a similar aim. Cavalli used a copper ring for closing the breech-joint, and he also tried a copper tube in the breech of his gun, which was rifled with two grooves for a plain iron shot. (See Plate I. figs. 2, 2a, and 3).

1846. The Swedish Baron Wahrendorf, before mentioned, affixed lead to the side of elongated projectiles mechanically, *thus*, and used a gun rifled with shallow flat grooves.

1847. Major Cavalli rifled an 8-inch gun, and attained good results, until the copper breech-ring was blown out. The breech of the gun subsequently gave way, just as happened in his later experiments in England.

1851. Wahrendorf's plan of coating the shot with lead was tried at Berlin with a 12-pounder rifled in six grooves, and a slow twist. The shells for this experiment were cast with two long and four short projections or studs, over which the lead coating was run. Wahrendorf also rifled guns with two grooves on a plan similar to that of Cavalli, but the lead coating, his own peculiar plan, was preferred by the Prussians. In Sweden, however, Wahrendorf's own country, the officers generally were opposed to the lead-coated or forced-ball system (so called from the projectile's outer surface of lead being larger than the bore, which necessitated loading at the breech), and a lieutenant in the Swedish navy named Engstrœm affixed hard wood bearings or buttons to an iron projectile. This plan was tried against Wahrendorf's lead-coating system, but nothing transpired as to which had the advantage, until, in the Annals of the Swedish Academy of Sciences, which were published in 1859, the preference was accorded to the Engstrœm system. Both plans were afterwards tested in France in 1857 by order of the Emperor Napoleon, but neither seems to have been considered as a great success. (In Plate I. figs. 4 and 4a, is shown the Wahrendorf gun.)

1856. General Timmerhans, of the Belgian Artillery, invented a wad which, by taking the rifle-gooves, gave rotation to elongated shot. His guns were rifled with two, four, and six grooves, with one turn in 18 feet, but the results were not sufficiently good to cause an adoption of the plan, which is shown in Plate I. fig. 5. Indeed every system that has been tried,

which does not give rotation to the ball from grooves in the bore, has failed in such manner as to show the impracticability of beneficially applying any other arrangement than that of rifling both gun and projectile.*

Not only plans of rifling, but also systems of breech-loading, have been continually brought forward, which have been sometimes identical with, and at others trifling modifications from, those of more ancient date; and it is also a fact that nearly every modern plan of grooving was used at least 250 years ago in muskets which seem to have been fired with round leaden balls. These necessarily gave little accuracy, and hence rifling did not supplant the smooth bore for muskets until an elongated ball was used, and it has not yet caused the smooth-bore great gun to be set aside. It should however be remembered that the mechanical fit was unknown in the early age of rifling, and it has been reserved to Mr. Whitworth to be the pioneer in the path of shaping the shot so accurately as to centre itself in a grooved gun. M. Cavalli certainly made very good practice with an iron shot, but this was from its tight fitting, which necessarily, like Wahrendorf's plan, required a breech-loader; but it was not until the precision of Mr. Whitworth's guns became known, that great accuracy from muzzle-loaders was regarded as even possible.

Breech-loaders—Wahrendorf and Cavalli.

The first breech-loading gun upon record was used by the English (and on this account I mention it) in 1428 at the siege of Orleans, but whether made in England or not is uncertain. France very early made breech-loaders, and her museums, as well as those of Strasbourg and Bavaria, contain breech-loaders of very early date, and in England there is also a large collection of foreign guns.†

Passing over, however, the breech-loaders of former years, it may be remarked that, in later days, not even the experiments of the elder Montigny, successful as they were, nor the later improvements of his son, succeeded in bringing breech-loading into general use; but, in 1842, Wahrendorf brought forward a plan which for simplicity and strength is still unrivalled. It consists of a round bolt passing through and across the breech, and supporting a valve from which a handle extends to the rear of the gun. When the gun is to be loaded, the bolt is withdrawn, and the valve pulled out by its stem or handle; and, when this operation is completed, the valve is pushed in, and the bolt shot across behind it; and they are then set tightly together by the turn of a screw upon the handle, which projects out of the rear of the gun. (Plate I. fig. 4). The effect of the discharge is to push the valve more tightly against the bolt, and the greater the force of the explosion the more is the valve itself extended. Even should an escape of gas occur, which is unlikely, no great damage can

* In preparing this account of foreign ordnance, the author has met with considerable difficulties, for so little is generally known that even the descriptions of otherwise credible eye-witnesses cannot be fully relied on, from their not understanding the points in which systems of rifling differ.—R. A. E. S.

† In the Museum on Woolwich Common is a French gun dated 1619, with a moveable vent-piece almost identical with that of the present service rifled guns.—R. A. E. S.

be done; but, in all the experiments, the valve, from being on the principle of the steam-piston, seems to have perfectly closed the breech. The gun of 1842 was designed for firing round shot which were covered with lead so as to close the windage. The plan was tried at Shoeburyness, and on board the "Excellent," but the results came far short of the inventor's expectations. Indeed, cutting off the windage entirely, from which such great results were formerly expected, is now found to be a disadvantage. Wahrendorf subsequently introduced an oblong instead of a rounded bolt for the breech apparatus of his rifled guns, and one of these is now under trial by the Ordnance Select Committee—the Service plan of closing the breech by a screw-stopper, and the later plan of effecting the same object by a pair of wedges, having proved equally unsatisfactory.

Cavalli's plan of breech-loading is very similar to that of Wahrendorf, but the apparatus is less simple. There were several of his rifled guns at the siege of Gaëta, but so many accidents happened with them in the trenches, that, on the bursting of a pivot-gun, which reduced the gun-boat to a wreck, the Sardinians, or rather the Italians, following the example of the French and Americans, abandoned the breech-loading, and are now only making muzzle-loading guns. Thus, while, after more than four centuries of trial, other nations are giving up the moveable breech because it does not unite perfect closing of the breech with the solidity essential for heavy guns, we are still going from plan to plan in the hope of effecting what will, even if successful in closing the breech, be scarcely safe with the heavy charges necessary to give the high velocity of projectile which is requisite for smashing armour plates.

But I must here go back a step to mention one, Treuille de Beaulieu, whose researches, following his previous experience of warfare, have so much influenced the rifling of the guns of European nations, and to whom France owes her present system. Long had he to struggle against opposition, and to bear the contemptuous treatment of his proposals by committees.

In the case of the elder Montigny, we have already seen that, although the Emperor Nicholas invited him to St. Petersburg, and the results were most satisfactory, the committee of the Russian Artillery, after putting all kinds of obstacles in his way, obliged the unfortunate inventor to discontinue his labours in their country; and but for this jealousy, so unfortunate for the Russians, they might have met us at Sebastopol with rifled guns.

French Rifled Muzzle-Loaders.

You will perhaps be surprised to hear that, so early as 1842, M. Treuille de Beaulieu addressed a complete paper on the subject of rifling guns to the French Artillery Committee, who, it is said, had not even the politeness to acknowledge its receipt.

In 1850 this artillery officer again urged his proposal, and this time the Committee, with a little more courtesy, did acknowledge the receipt of his letter, but this was the extent of attention they gave the subject.

Now we have seen first one committee rejecting a system for rifling, which deprived the Russians of a weapon that might have gone far to counteract their disasters in the Crimea, at Silistria, and at Bomarsund;

and we have seen a second throwing aside a plan, which deprived France, during its contest with the Russians, of a weapon that gave such remarkable assistance in their subsequent combats with Austria.

Colonel Treuille de Beaulieu's paper would probably have remained to this day in the pigeon-holes of the French Committee office, had not the Emperor, persuaded that smooth-bore guns were not equal to the requirements of modern warfare, stirred up the question of rifled arms, and led to the production of the artillery colonel's paper, somewhat about the time that Lieutenant Engstrœm's plan was under trial in France. I may here venture to remark, that a despotic prime minister, who, despite committees, and in defiance of precedents, will take upon himself the responsibility of ordering the trial of a system which gives reasonable hope of success, and on a sufficient scale to test its merits, only endears himself the more to the people as a thorough patriot; and, as such, all must esteem Lord Palmerston, and admire his decision for an immediate trial of a battery of Mr. Whitworth's guns. Excuse this little digression, and I will return to Colonel Treuille de Beaulieu, and what he has done for the French artillery.

The French Emperor, after satisfying himself of the superiority of the Colonel's plan over that of Engstrœm's wooden bearings and Wahrendorf's lead, at once rifled some brass pieces, and sent them for immediate service in Algeria. Here their success was apparent, but the guns were considered too heavy, and, on receiving this report, the Emperor rifled his light brass pieces, and thus, at a very trifling expense, France was placed in possession of the artillery which was soon to do such good service in the field. These pieces consumed their usual powder and their ordinary shot as well as fired the elongated projectile, an arrangement that enabled the French to cut up the astounded reserves of Austria when at a distance, and to overthrow their squadrons at close quarters by the unfailing case-shot. The repulse of the Austrian cavalry is worth recording—they had formed in the plain, and were seen from the heights bearing down upon the thinned and wearied columns of the French infantry, when the order "load with case" was given to the artillery, and, as the cavalry dashed onwards, burning to achieve a victory, they were met and rolled over by a shower of canister-balls that sent back many a charger riderless, leaving gaps in their ranks which hopelessly disordered the survivors, and prevented them from again returning to the charge.

The rifling of the French bronze field-pieces that did this execution consisted of six rounded grooves, and the projectiles had twelve zinc studs* or buttons placed in pairs (see Plate I. fig. 6), one stud being arranged so as to push the bearings of the shot tight against those sides of the groove on which it would press in coming out, to prevent an injurious play on the shot's starting. The weight of the gun is about 6 cwt., and

* The French sloped off the bearing side of the buttons to the angle at which they were found to have been rubbed down by the rifle grooves on discharge, and they attributed much importance to the use of zinc; but have latterly discovered that accuracy of adjustment of bearing is alone required. The rubbing down aslant merely showed that the projectiles were not preserved concentric in their passage out of the gun. One of the projectiles fired at Solferino is in the Museum of the Institution, together with various rifle-shot used in England.—R. A. E. S.

that of its rifle projectile 9lbs., and it was this lightness which enabled Tartar ponies to draw the French field-pieces through the marshes of China, in which our own guns of 8½ cwt., and mounted upon heavy carriages, stuck; a defect which is about to be remedied by introducing an Armstrong gun and shot of the same weight as the French.

Besides these field-pieces, the French, after careful trials of the two-grooved elliptical rifling for larger ordnance, gave it up for three centrical grooves in December, 1860, and, as the plan was simple and inexpensive, they at once carried it out with their heavy guns, and were again ready for the contest. The ordnance thus treated were cast-iron 30 and 50-pounders, which were rifled so as, in addition to their usual smooth-bore ammunition, to throw shells of 60 and 89lbs., containing 5½ and about 8lbs. of powder respectively. These guns were strengthened by hoops put on the breech. (*Vide* Captain Blakely's Lecture, vol. iv. p. 401 of the Journal of the Institution.)

The projectiles, instead of having twelve studs wholly of white metal, were fitted with three large studs, one half of which were of zinc, and the other half cast on the shell. (See vol. v. page 434, plate ii. of the Journal). The rifling of the gun commences from straight, and increases gradually in quickness of turn from breech to muzzle, the object aimed at, being to allow the projectile to move easily at the first impact of the charge, so as to lessen the strain upon the breech. This is, in my opinion, a mistake, for the studs strike the sides of the rifling very hard, which, besides wearing down the edges of the grooves, breaks off portions of the studs, occasioning an erratic flight to be taken by the ball. These studs are also liable to injury from carriage, and flattening by a fall. In both cases there might be a difficulty in loading, and they are not safe for firing over ships or advanced works.

In the cast-iron service 32-pounder, which was rifled on the French plan, and tried at Shoeburyness, the zinc was put upon the wrong side of the button, so that in loading the zinc pressed against the grooves, and, on coming out, the iron came in contact with them. The consequence was, that, in 40 rounds, the iron had knocked away the edges of the bearings of the grooves, and rendered the gun unserviceable; but, despite these disadvantages, the practice so impressed one of the competitors, that he said, "Well! that *is* a good plan!" and, as his own gun was in trial, we may take what he said as of some value.

In addition to these naval guns, the French have some light brass mortars, which are likely to prove useful for dropping shells upon the deck and into the engine-room of a foe.

Austrian Rifling.

The Austrians, taught the value of rifled pieces at Solferino and Magenta, must be admitted to be not bad judges of the worth of the French plan. Their first trials of rifling commenced about 1857, and were continued through 1858 and 1859 without any decision being arrived at; but, on the 4th April, 1860, after some previous experiments, breech and muzzle loading rifles, and lead-coating and French studs, were tried against each other. On this occasion the Emperor was present, and a

unanimous decision was given in favour of Treuille de Beaulieu's plan, because—

1st. It could be quickly and cheaply carried out.

2ndly. It united facility of fire with sufficient accuracy.

3rdly. It combined in one piece the advantage of the gun and howitzer.

4thly. It allowed of the employment of all the existing material.

But mark, Austria is not satisfied that she possesses the best gun, and, since February, 1861, has been making trials of three systems of rifling. She is also making experiments with a new metal for ordnance, and has lately obtained excellent results from gun-cotton, which has been fired from short and thick-chambered pieces of bronze. (See Plate I. fig. 7.)

Austria, like France, Spain, and other countries, has made trials of finely-grooved breech-loaders on a plan similar or analogous to that adopted in this country, and did intend in 1859 to cast breech-loaders at Marcazell, but decided in 1860 that any advantages in accuracy from centering the projectile on so many points was more than counterbalanced by the greater delicacy and expense of lead-coated shot, and the want of solidity resulting from a breech-loading plan.

Russian Rifling.

The Russians are now endeavouring to make up for lost time, and to rifle the heavy ordnance, mounted on their various fortresses, on a plan similar to that of the French. They have already purchased portable rifling machines from Messrs. Vavasseur and Co. of London, with the intention of grooving the guns without moving them off their carriages; and they also mean to use the rifling machines in a similar manner on board some of their ships; but their larger guns*—120-pounders of $10\frac{3}{4}$ inches bore, firing a hollow shot of 120lbs. (the solid would be about 160 lbs.) and the 56-pounders, which are like the American columbiads—they now intend to rifle. (These guns are shown in Plate I. figs. 8 and 9.)

The Russians had rifled several of their smaller fortress guns (30-pounders and 24-pounders) with six grooves, and their field-pieces have been mostly rifled in a similar manner, but, instead of placing the studs in pairs, and having twelve of them, they use only six placed alternately. Their rifling has an equal twist, and the grooves are slightly narrowed at the bottom. In the field-piece they are sloped off on one side to allow the projectile, the bearings of which are also sloped off, to wedge itself tightly; but these slight modifications, which have been also tried in France, possess no advantage over the fittings adopted for the French service. (See Plate I. figs. 10 and 11).

Swedish and Dutch Rifling.

In Sweden, Baron Wahrendorf's own country, Lieutenant Engstrœm's

* These guns are, it is believed, to be strengthened at the breech by hooping, and may then be rifled in three grooves to fire a projectile with long iron bearings instead of studs, as the Russian trials with this plan have been satisfactory. An officer was lately in England gathering information respecting the English experiments with iron shot.—R. A. E. S.

system was preferred; but the French plan is considered still better, and is the one now used.

The Dutch have also preferred the French system of rifling and have applied it to bronze guns. The reasons for this almost general adoption are given in very similar terms to those made use of in France, viz. that M. Treuille de Beaulieu's system was—

The simplest;

The quickest and easiest to carry out;

The cheapest, and involved no complications.

Spanish Rifling and Strengthening for Cast-iron Guns.

The Spaniards rifled their field-guns on the French plan, and used them against the Moors at the siege of Tetuan, and—as an author, M. Mangeot, whose researches I have largely availed myself of, states—"taught the Moors by improved weapons the advantages of civilization."

Their heavy guns have, like the French, been lately rifled with three grooves, the only difference being that the twist of the rifling is uniform, and that the projectiles have studs in pairs instead of one large stud only for bearings. (See Plate I. figs. 12 and 13.) Spain has also followed the example of France in hooping her heavy ordnance, having previously ascertained that the unhooped cast-iron guns rapidly deteriorated, and ultimately burst at less than 200 rounds, but that the hooped guns, when properly fitted, which was arrived at by careful experiment, always stood more than 1000 successive discharges.

The final decision of the Spanish Committee is thus given: "The path we must follow is clearly indicated,—cast-iron cylinders hooped, a most simple manufacture, which, once established, only requires great care in securing the proper diameter to the bore of the hoops. The difference between the diameters of the hoops and of the cast-iron part must be determined by experiment aided by calculation."

Sardinian Rifling.

The Italians made several trials of Cavalli's system of rifling in two grooves at Turin, and ultimately decided that the ribs on his shot were unfit for field-pieces. These ribs projected too far for the size and weight of the shot, and consequently stopped the rotation, and materially lessened the range. The tightness of fit was found also to be a serious objection to using the plan for muzzle-loading.

At the siege of Gäeta many of the guns used were grooved on the French system, and some threw zinc-ribbed shot similar to those used in the Armstrong shunt: but the guns for these last, and a crowd of various small calibres of guns, were gradually suppressed, Cavalli's and Wahrendorf's systems abandoned, and breech-loading entirely given up. The "Revista Militare" of Turin, dated 1859, contains, according to Fourcault, a full account of the failure of the breech-loaders, and states that the accidents which happened had been fully anticipated, the plan being unfit for heavy guns; and thus the Italians, having first adopted the French plan for field-pieces, now took it in its entirety for heavy guns also.

Prussian Rifling for Cast-iron and Steel Guns, and Belgian Rifling and Bessemer Metal.

But are any nations using the lead-coated shot? Yes; the Prussians, who first adopted breech-loading and a compression plan.

They have had a large number of steel field-pieces made by Krupp of Essen; these weigh 800lbs. and throw projectiles of 13lbs.; but their heavier guns are cast from charcoal iron of a very superior quality; but mark, with these rifled guns the Prussians have retained several smooth-bores, so as not to lose the advantages of the straight ricochetting and rolling of the round ball. Their field-gun is given at Plate I. fig 14.

The Belgians also, impressed by the accounts of the immeasurable superiority of the English rifled piece, and influenced by Prussia, seem to have very lately decided upon lead-coating, but have wisely adopted a slight modification of Wahrendorf's plan of closing the breech; this differs from the Armstrong in that, while a little extra pressure forces the breech-stopper (vent-piece) of the latter away from the end of the bore, causing a dangerous escape of gas, the valve face of the Wahrendorf stopper is only more fully expanded and the stopper more tightly pushed against the bolt which supports it in the bore of the gun. [Shown by a model on the table].

The Belgians are also testing Bessemer's steel for rifled guns, and have, as far as their trials have gone, found it to be a very superior metal; and, as it can be produced at comparatively small cost, they will probably largely employ it.

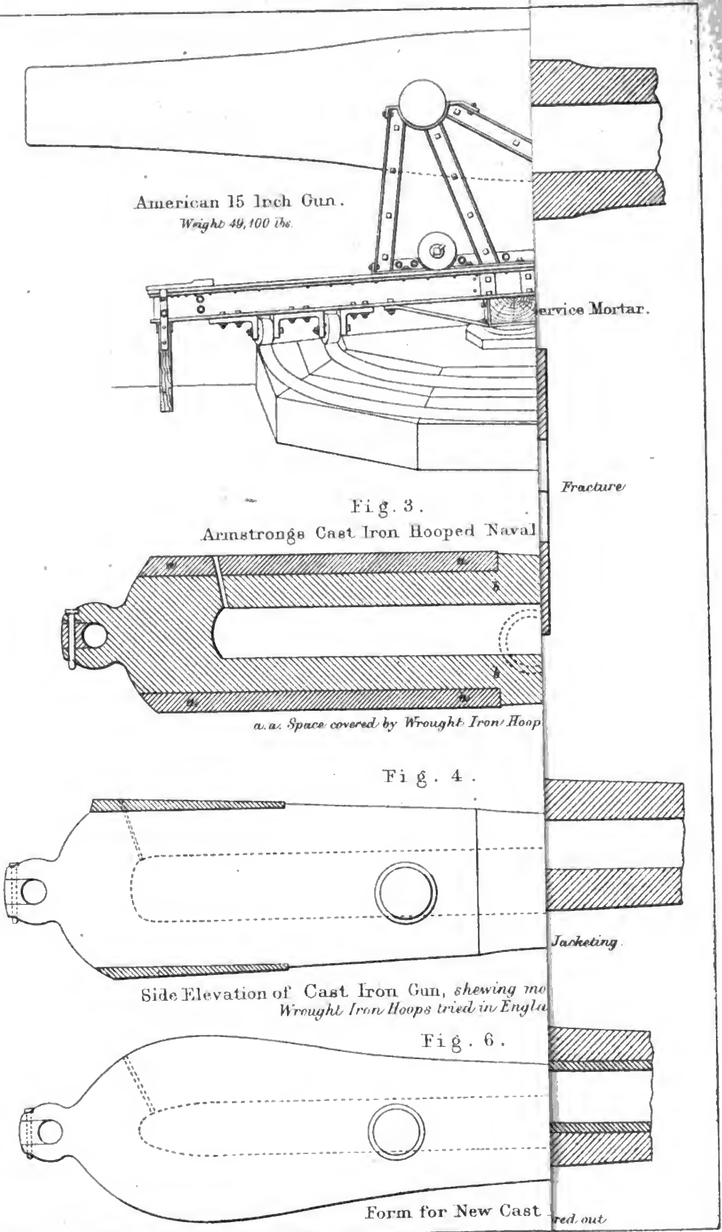
In England, Bessemer's own country, his metal has not yet been tried by Government, but it was used in one of Mr. Whitworth's guns.

Portuguese, Swiss, and Egyptian Rifling.

Not to fatigue you by further details of the guns of European countries, I may mention that, besides the nations spoken of as having preferred the French system on account of its simplicity, its allowing of the use of the old ammunition, and combining the advantages of the smooth-bore and rifle,—the Portuguese, the Swiss, aye, even the Egyptians, have, after careful trials, condemned breech-loaders and delicate projectiles as unfit for the rough usage of war, and have followed the safer plan of rifling their present guns and using elongated shot as well as all their present ammunition.—(Fourcault, "Le Canon Prussien," edition of 1861).

American Large Iron Guns, cast hollow.

But it is time to go across the water to the Americans and to examine what they have done. You must all have heard of the Dahlgren and Columbiad guns. The former is in shape very like a soda-water bottle, being much rounded over the breech; the latter is rather a straighter gun; but of the large weapons, which alone seem to be in favour in the States, their 15-inch-bore guns are the most in favour. (*Vide* Plate II. fig. 1.) The gun represented was cast hollow at the Pittsburg foundry, under the direction and after the method of Captain F. J. Rodman; it weighs 49,100lbs., and is 165 inches long in the bore; the thickness of metal


American 15 Inch Gun.
Weight 49,100 lbs.
ervice Mortar.
Fracture
Fig. 3.
Armstrongs Cast Iron Hooped Naval
a. a. Space covered by Wrought Iron Hoop
Fig. 4.
Jacketing.
Side Elevation of Cast Iron Gun, shewing mo
Wrought Iron Hoops tried in Engla
Fig. 6.
Form for New Cast
red out

J.R.Jobbins

through the sides of the gun at the junction of the bore with the chamber is 16½ inches, and the thickness of the metal at the muzzle 5 inches.

This gun had fired 350 rounds before the middle of last year with shells weighing from 305 to 335lbs., and an average charge of 35lbs. of large-grained powder; it was worked with facility, requiring from 1′ 10″ to 1′ 52″ to complete loading, running out, training, and firing.

At 6° elevation, the shot struck the ground at 2017, 1937, 1902, 1892, and 1878 yards; the lateral deviations being 1, 3, $\frac{2}{3}$, 5 yards to right, and 5 yards to the left. The time of flight was from 6½ to 7 seconds. The initial velocity was found by experiment to be 1328 ft. per second with 40lbs. of large-grained powder, and 1282 ft. per second with 50lbs. of perforated cake.

At 28° 35′ elevation, the range of this gun with shell of 334lbs. was found to be 5,200 yards with 50lbs. perforated cake, and 5,400 with 40lbs. of large-grain powder; the time of flight being about 27 seconds.

The large-grain powder used, differed from common powder only in the size of the grains, which are $\frac{6}{10}$ inch cube, and in the degree of pressure to which it is subjected in manufacture.

The perforated-cake powder, invented by Rodman, is prepared in solid compressed cakes (subjected to a pressure in the making equal to what they will be subjected to in the gun), and perforated with holes to permit access to the flame; it is intended to reduce the excessive strain to which very large guns are subjected with fine-grained powders, which are inflamed almost instantaneously, and before the heavy projectile is started from its seat. This was ascertained by the "pressure gauge" attached to the gun, or introduced into its chamber; and the comparative initial pressures of "perforated cake," "large-grained," and common cannon powder, were thus found to have about the ratios of $\frac{1}{7}$, $\frac{1}{3}$, and unity. This, writes Major J. Barnard, of the U. S. Engineers, is a result of very great importance in its bearing upon the practicability of using cast-iron guns of extraordinary calibres.

Speaking of rifled guns, Major Barnard says range and accuracy are of little value unless the projectile possesses the necessary destructive qualities. And again, "to damage a vessel seriously it is not the hole-punching property which we need; it is the smashing effect, the staving in of planking and timber; or, if a hole alone is made, that it shall be so large as to defy plugging."

The Americans are abolishing 24 and 32-pounder guns, and substituting Columbiads and Dahlgrens, rightly considering that such small-bore guns will be of little use in a future conflict. The early guns had a large chamber of less diameter than the bore itself, but this was found very objectionable in practice, as the shortening or reducing of the charge left an air-space which endangered the safety of the gun. During the last war with England the Americans used a very thin metal instead of flannel to cover the powder, in order to prevent the necessity of sponging at close quarters; and they have lately succeeded in making their powder water-proof. Another of their plans is to cover their old round shot with pulp to reduce the windage, which is, even in the 15-inch gun, only $\frac{1}{10}$ of an inch; we, however, foolishly continue to give a windage which was necessary some

50 years since, when balls could not be cast truly spherical, but which with the exactness of the present castings, under the very able superintendence of the head of the Laboratory Department, could be now advantageously reduced by one half.

American Strengthened Rifled Guns.

The Americans have rifled their field-pieces, and have been rifling some of their heavy ordnance; the "Parrott" gun is merely a cast-iron piece rifled and then strengthened by hoops on the Blakely plan. (See Plate II. fig. 2.) The Times' Correspondent writes thus: "The Parrott gun, made by the eminent founder at West Point, is a simple workmanlike-looking piece of artillery, with a thick iron band shrunk over the breech, and its range is nearly as great as that of the Armstrong, and its cost very much less;" and again, "Captain Dahlgren informed me he was surprised to find we were content with iron in our guns of such inferior fibre;" and also, "in the qualities of iron the Americans say our standard is much lower than theirs."

This opinion seems to be borne out by the unequal expansion of the cast-iron guns which were lately attempted to be strengthened by tubing (see page 18), when the bending, on heating, occasioned the destruction of two guns before one could be successfully tubed; and in the English work on "The Useful Metals" it is stated, at page 213, that "The quality of our pig-iron has deteriorated within the last half-century. In an English gun imported into America in 1845, the cast-iron was of a density of 7.04, and tensile strength of 18.145lbs. to the square inch; while other English guns, imported about thirty years previously, contained metal of a density of 7.202, and tensile strength corresponding to 28.067lbs. to the square inch."

The Americans have invented many breech-loaders, and amongst others a plan which they supplied to this country, at a cost, of, I believe, 10,000*l.* including the six guns and patent. These six guns are still lying near where they were landed in the Arsenal, quite unfit for use; they are rifled with several shallow grooves similar to those used by Prussia, and were intended to fire lead-coated shot.

The Americans, however, carefully eschew the use of breech-loaders, though they seem to have been at first favourable to compound projectiles. The Southern Confederacy has purchased very many of its heavy guns from England, which, with few exceptions, fire lead-coated shell. At the cannonading against Fort Pickens, these leaded projectiles struck on their base, which was heavier than the front, and did not explode; the range obtained was, however, sufficient to show the value of rifled weapons, for the smooth-bores mounted in Fort Pickens were unable to reply to the distant bombardment.

The value of rifled guns was equally shown in the chase of a small Confederate steamer by the North American frigate "Minnesota;" for the former pitched several rifle shells upon the latter's deck, causing very serious damage, and some loss of life, while keeping quite out of reach of the latter's smooth-bore guns.

It only remains to add, that the Americans have rifled their field-pieces,

and are reducing their guns to as few calibres as possible, following in this the example of the French, who are, it is said, bringing the mass of their ordnance to 4 calibres, viz., 1 for the field, 1 for the siege, and 2 for naval purposes, viz. 30 and 50-pounders; and this wise plan is also being followed by Austria and Sardinia.

Having thus examined what continental nations and our cousins across the Atlantic are doing, it will be well to compare our own progress with what they have effected at so small an amount of effort and expense: in fact, foreign countries have, for the most part, given to their old guns by rifling a very great increase of range, and obtained greater effect by the use of elongated shells, still retaining the use of their former ammunition.

English Rifles; Solid Round Shot and Shell Guns.

England, however, unrivalled in resources and in manufacture, has adopted a new gun, and with it a principle of rifling, which cannot be applied to her old artillery; she is therefore, like Prussia, obliged to retain smooth bores, and thus to have two guns to perform the work of one; and, while most other countries are reducing the various kinds of ordnance to four or six sizes of bore altogether, we have already seven or eight small calibres and about 20 varieties of Amstrongs, in addition to as many or more different diameters and descriptions of smooth-bore guns. Awakened, as we were, from our complacency respecting the old ordnance, we have very much over-estimated the effects which would be produced by rifled ordnance, and hence have neglected the improvement of our cast-iron guns; and, as the Armstrong system could only be applied to specially constructed weapons, the smooth-bores were at first virtually put aside, being regarded by those who had little experience of warfare with something approaching the contempt entertained for "Brown Bess." This did not, however, lead to stopping the supply of cast-iron ordnance, and we have continued to receive shot and also *shell* guns, which answered well whilst the round ball and the round shell were alone fired, though, even then, the larger guns were barely strong enough (from being cast of bad form and solid instead of hollow); but now that round balls are only valuable within 600 yards against plated ships, and shells of little or no use against them, their form, size, and mode of manufacture, are evidently unequal to the requirements of modern warfare.

English Plans for Strengthening Cast-iron Guns; Casting upon a Core; and Remarks upon English and French Rifling.

In manufacturing the new artillery, difficulties soon arose, and it likewise became evident, that the force required to squeeze a leaded ball through a barrel of smaller size than itself threw a strain upon the weapon, which increased in a very rapid ratio as the size of the bore increased. The shunt method of rifling had been tried with a cast-iron service 32-pounder in 1859, and this gun bursting at the 50th round, indicated that an increase of strength was necessary, and therefore "hooping," which had been proved a success when applied by Captain Blakely in 1856, was again resorted to.

Instead, however, of hooping the existing ordnance on a plan which had proved successful, a new pattern weapon, which was thick in front of

the trunnions, and very thin at the breech, was supplied. (See Plate II. fig. 3.) But as the hooping, *a a*, did not unite the cast-iron to the wrought-iron bands, the weapons had so little longitudinal strength, and were so weak at *b b*, where the thickness of cast-iron was suddenly reduced 2 or 3 inches, that the guns proved unsafe.

The next plan tried was that of casting gun-metal upon these iron weapons; but the molten brass, after *burning* the iron it was thus cast upon, proved to be so yielding, that the iron breech burst and opened about an inch without any (apparently) great strain being thrown upon the brass. Captain Blakely was then permitted to try to utilise these new iron castings, and his method has hitherto stood the proof, in the only gun altered by him. Subsequently, a plan of binding the breech to the rest of the gun was tested, the piece being cased in wrought iron, and bound together by longitudinal bands attached to its trunnions; but the results were very disproportionate to the expense. The mistake of trying to hold on the breech longitudinally has arisen from the gun's breaking against the thick breech on bursting; but it is in reality first fractured at the seat of the shot, and then flies open, breaking off the pieces on each side. A cast-iron gun goes gradually, of which indications are generally given by minute cracks, which gradually enlarge, but can only be seen round the vent hole. Another plan of strengthening was that attempted by inserting a tube of steel or wrought-iron inside the larger cast-iron ordnance which were proportionately bored out; but the difficulty of getting the proper amount of tightness, the weakening of the gun where the tube abutted against the bottom of the bore, and the fact that if put in without damaging the piece the tube might crack and the gun burst without warning, will always render such a method as unsafe in practice as it is difficult and expensive in its application (see Plate II. fig. 8). The last plan of strengthening tried is that shown in Plate II. fig. 4, but, as the thickness of the wrought iron was at the breech end, no advantage resulted from its employment; and thus, strengthening cast-iron guns has been pronounced a "fallacy," and, as it appears, is definitely condemned. The Armstrong gun itself is, however, a proof to the contrary, and affords an example of the union of two different irons, (the grain of the one crossing the grain of the other,) yet resulting in giving that strength which was found unattainable prior to the use of the forged breech, to which the coil tubes are welded: another example was afforded by Captain Blakely's strengthened gun, which was fired at Shoeburyness in 1856, and threw 2,389 shot, whilst 479 shot only were fired from a brass piece before it was disabled, and 351 and 137 respectively from two unstrengthened cast-iron guns before they burst; the powder charges being very great in all four cases.

It has been stated that the French ordnance is not stronger than before it was hooped; it is possible that this might appear true under a similar test to that used in England, which consists in increasing the weight of the proof-cylinder by the weight of one of the gun's shot every 10 rounds (by which means the strain is made to act in a different manner and direction to that thrown upon the gun when firing the proper service charge); but it is not true as respects the ordinary endurance, which is rendered much more uniform and continuous by hooping.

I may remark, that all guns properly cast are sufficiently strong to resist a few rounds of very heavy charges, but by using them the particles of iron would be disturbed, and then would not re-arrange or re-settle themselves unless a long period of rest were given.* With smaller charges, cast-iron guns slowly deteriorate with constant use, but they become very rapidly weakened if fired continously, so much so, that, were a gun to be fired rapidly for 300 or 400 rounds and then proved with a heavy charge, it would almost inevitably burst. The object therefore to be aimed at is, to prevent the disturbance of the particles, and the consequent deterioration of the piece; and this is what the hooping *does* effect, when the gun is fired with the charges which the hoops are calculated to withstand; should a greater strain, however, be thrown on the gun, the hoops first become strained, then break, and the cast-iron, relieved of its supports, goes also.

These hoops, if well manufactured, will give very great support to the gun from the strain upon them being "tensile;" this will account for the success of the Spanish experiments in strengthening, in which the hooped guns withstood 1,200 rounds uninjured, while similar unhooped pieces burst in less than 200 rounds.

The guns tried in Spain were all 32-pounders, which were rifled on the plan previously described, and fired with about 7lbs. of powder and projectiles weighing 60lbs. Unlike a smooth bore, in which the ball rolls over and starts at once, rifling, besides weakening the gun in proportion to the depth of the grooves, greatly increases the strain by detaining the shot; and it is the lengthened period the breech has to withstand the great pressure, resulting from the reduced windage, the detention of the shot, and the combustion of a larger portion of the powder charge before the shot starts, which is so destructive to the endurance of rifled cast-iron ordnance.

It is undoubtedly true, that a more fibrous structure than is to be met with in the present cast-iron, is required for powerful rifled guns; but we have so greatly neglected to make the best use of cast-iron, that both our guns and our mortars have been cast of a form which is not only weak, but also tends to their destruction.

* Many experiments have shown the destructive effects on cast-iron ordnance from continuous firing, as also the increased strength resulting from long rest; and, by allowing two or three months or more to intervene between the series of discharges, a very much greater number of rounds may be safely obtained than in the case of almost daily practice with the same gun: the endurance is also much affected by firing at high elevations, at which the weight as well as friction of the shot has to be overcome, and little or no relief is afforded by recoil. At page 218 of the work on "The Useful Metals," published in 1857, it is stated that "pieces cast some years before testing stood several times the quantity of firing of other pieces cast but a few months previously." The tensile properties of the metal did not explain the difference; and the form, dimensions, weight, method of casting and cooling, and the manner of proving, were the same in all the pieces tried. Casting hollow, or, as it is termed, upon a core, instead of solid, very materially increases the strength and the endurance of guns, and is, therefore, always used by the Americans for heavy ordnance. In England we have likewise had similar results, for while there is, it is said, no record of any 13-inch mortar bored out from the solid, standing 700 rounds, there are at the present moment two mortars in the Royal Arsenal which were cast hollow, and have respectively withstood 2,000 discharges.—R. A. E. S.

Mortars.

The effect produced by this faulty form was seen in the bombardment of Sweaborg, when nearly the whole of the mortars employed either burst, or were rendered unserviceable; the best, that of the "Growler," cast in 1813, standing 355 rounds only.

By a reference to the drawing, it will be seen that the trunnions prevent the expansion of the iron at the places where they unite with the piece; hence, as the iron warms, it expands at the bottom, and the mortar being supported upon its trunnions, a severe shock is thrown upon that part which is in the line of least metal, and has been further weakened by expansion; the result is, a gradual disturbance of particles and rapid deterioration, until at length the mortar opens and generally splits in two pieces, much as if chopped down by some instrument. (See Plate II. fig. 5.) An inspection, however, of the remains of the mortars will afford convincing proof that some cause was at work to produce such very similar results, and will show how little our mortars are to be relied on for continuous bombardment. The mortars might, however, be strongly hooped at the breech, and then they could be rifled so as to throw incendiary shells of very great capacity.

Doubtless the placing of the trunnions at the re-inforce would greatly increase endurance and give other advantages, but the solution of this important question is now to be looked for in short and comparatively light rifled guns of large calibre, to fire elongated shells of very great powder or molten iron capacity, either horizontally or at mortar elevations.*

Destructive Effects of Air Space in Guns.

Having thus endeavoured to show the faulty shape of our present guns and mortars, and that no plan affording reasonable ground to hope for success has yet been applied for strengthening them, other than that proposed by Capt. Blakely, which proved successful, I may now mention, in proof of the little attention paid to the improvement of our heavy naval guns, that, although the bore has been constantly observed to have been expanded near the seat of the shot—in reality between the powder and shot—the cause was not known until the "proof" of the Sardinian ordnance. It was then found out, owing to the damage done to so many of the guns; and, as a very thick wad was used, attention was directed to this point; the result was, that the damage was found to have taken place just where the wad lay, and it thus became evident that the compression of the loose wad left a considerable air space, and caused the damage. In the service cast-iron guns, the metal of which is turned down at the seat of the shot, where strength is most required, and are disproportionably

* Howitzers mounted upon rotating mortar beds of modified construction, and supported by elastic rings to absorb recoil, would be especially useful for firing into port-holes, or for sweeping the decks of ships, and the banks and shores of rivers; they might also be advantageously used for dropping molten iron shells upon the unprotected parts of vessels, or into dockyards, &c. At great elevations the rifled howitzer would carry its elongated projectile beyond the present mortar range with less than half the mortar charge of powder.—R. A. E. S.

thick at the breech, the use of a soft wad, or making the rear of the projectile of tapering form, which leaves an air space, greatly diminishes the endurance of such ordnance when "rifled;" hence, in testing the relative strain of different systems of rifling with these guns, it is necessary to use projectiles of similarly shaped base. It had been long known that a wad placed between two shot in a smooth bore caused them to break up, and that red-hot shot which were fired with thick wetted junk wads endangered the piece, but no application was made of this knowledge; there can be little doubt, however, that the "proof" has much damaged our cast-iron guns, and that the system on which both the Armstrong and smooth-bores are tested, and on which all our tests for endurance are conducted, needs considerable alteration. There is a story told of two gun-makers respecting this point. One of them had been sending down his guns to have them proved, and a great number had burst. He asked the other how he managed, that his guns answered so well. He replied, "That is my secret"; but, being pressed to explain the cause, at length said, "I do not prove my guns at all."

Proposed Form for New, and Plan for Strengthening Present, Cast-iron Ordnance.

But it is time to point out the shape that is likely to give good new cast-iron guns, and also the plan that promises to utilise our present stock, and to convert it into rifled ordnance at a moderate cost; but, even if not afterwards rifled, it would be certainly advantageous to strengthen the guns of 8-inch bore; for, in the case of the 68-pounder, a powder charge of 20lbs. or more, and a tighter fitting shot of about 72lbs., could then be projected with a much higher velocity than that obtained by the 68-pounder ball at present used. The *rifle* charge for cast-iron guns should be about half the *round-shot* charge, which would produce about an equal strain up to an elevation of 5°.

With respect to new guns, the form shown at Plate II. fig. 6, is proposed, the piece being chambered to lessen the re-action against the bottom of the bore. This shape will give thickness and rigidity where the strain comes, and prevent the disarrangement of the particles by the great force exerted, tending to pull open the bore at the seat of the shot. The guns will also expand equally on warming, and thus two elements of weakness—unequal strength and unequal expansion—will be got rid of; and, if the length be slightly reduced, new guns of 8 and 10-inch bore could be cast to fire solid balls instead of the present ineffective round shell—which can alone be fired from all the 10-inch and the 8-inch, (except the 95 cwt. guns supplied to the "Warrior" and similar vessels)—without any increase of weight, or any extra cost.

The strengthening of the present ordnance would be best accomplished by a single wide coil or jacket (see Plate II. fig. 7), forced on cold by carefully measured hydraulic pressure, which could be effected at very small expense. The new and the strengthened guns could then be rifled, and fire the elongated projectile in addition to the usual smooth-bore ammunition. This strengthening might be applied to all guns from 18-

pounders upwards, inclusive, by which means rifled weapons would be at once attained at moderate cost; these might, when unserviceable, be replaced by guns of a better material, such as strong hollow forgings, coil-jacketed from breech to trunnions, with a wide hoop over the jacket at the seat of the shot; this arrangement would leave the tough forged muzzle—the exposed portion of the gun—to withstand the blows of hostile shot; or else they might be replaced by hooped castings of Bessemer's steel, a metal which will be probably employed ere long for making shot. Of 18-pounders we have a large number, and it is probable that these, if rifled and strengthened as indicated, would be quite equal to the 40-pounder Armstrongs (the largest guns, next to the 100-pounders, which have hitherto proved sufficiently satisfactory to be manufactured in large numbers) for ship use. The bore of the 18-pounder is considerably larger than that of the 40-pounder, which would be advantageous; and the expense of its rifle projectiles would be only perhaps a third of those which have been supplied for the Armstrongs, and the cost of its round ball perhaps not more than one-fifth that of the solid 40-pounder Armstrong shot.

Armstrong Guns—Whitworth and Armstrong Competition.

Having thus endeavoured to show the small reliance that can be placed on our mortars, how the present guns can be utilized, and new strong guns cast, it remains to speak of the Armstrongs, which are being introduced into the service so fast as to bid fair to supplant the cast-iron pieces. These guns are made up of coils which are not adapted to withstand blows from hostile shot, and they are grooved too finely to stand exposure and rough usage, or to fire any other ammunition than the lead-coated projectiles specially designed for them. The calibres vary from a bore which is a little larger than a 2-pounder to one larger than a 42-pounder, or, as usually denominated, from 6 to 100-pounders. Of these, the 12-pounder field-piece is to be replaced by a 9-pounder for the horse artillery, which will give two weights of shot, viz. 9 and 12lbs. for the same field-work. In the Chinese campaign the 12-pounder was found too heavy for the marshy ground, nor was its destructive effect commensurate with its accuracy of fire. Sir Robert Napier's dispatch, given in the Times of November 5th, 1860, speaks of the Tartars advancing on more than one occasion despite our fire, and it is said that Desborough's troop alone prevented the sabring of the gunners who were working a couple of the Armstrongs. On board ship, the guns have hitherto proved to be dangerous, requiring a caution which is impossible in any case save in target practice, or very distant firing; and the guns have been also found to be inaccurate if at all corroded by rust, or if mounted upon a quickly moving platform. Contrary to what is generally believed, the competition between the Armstrong and Whitworth 12-pounder strikingly exhibited the inferiority of lead coating, for the projectiles deviated from the line of aim considerably more than those of simple iron, and at 10° ranged very unequally and much less; and, as on board ship a gun is never upright for two consecutive seconds, the Armstrong allowances for deflection could not be correctly calculated. The report of firing is annexed (see Tables, pages 28, 29). In practice

also difficulties occur, for the shot cannot be re-fired, and, if the charge be reduced, the accuracy is lessened and air space has to be carefully provided against.

At close quarters, at which decisive actions will ever be fought, the Armstrongs are very inferior in smashing effect, and the many niceties of adjustment necessary to ensure safety will, when men's nerves are highly strained, be certain to result in appalling accidents; for the mere want of tightness is certain to cause a leakage of gas, and to convert portions of the breech apparatus into destructive missiles, at the same time that a suffocating vapour from grease, lead, &c., would fill the deck.

That this is not a highly-coloured picture, is evident from the narrow escapes of the crews in the "Trusty," "Illustrious," "Edgar," and "Marlborough," in which last vessel the cabins and furniture were reduced to a wreck, the gun's crew thrown down, and the captain of the gun scarred on the face; and for this accident there was no apparent cause, but only a suspicion that some grit had stopped the vent-piece from going down properly.

As pivot-guns this ordnance is still more unsuitable, from the numerous delicate parts of the weapon liable in this exposed position to be hit by the grape or case of an enemy; and, if the wedge plan of breech-loading be adopted, the spreading out of two wings or wedges, one on each side of the breech in loading, will increase the chance of the guns being disabled, and the crew hurt by the fragments.

Breech-loaders for Pivot Guns.

It is a mistake to suppose breech-loaders to be well adapted for pivot-guns; the contrary is the case, for, such guns being intended to be fired at great elevations, should be as solid as possible in the breech; the strain upon the rear being very greatly augmented as the elevation is increased. Not only so; but the gun, which has perhaps just got the range, must be brought horizontal before loading, by which a considerable time, and probably accuracy, is lost between the rounds; and, as the muzzle of a deck gun can be easily got at for loading, there seems no reason for opening and weakening the breech, and complicating what can be otherwise better done from the muzzle.

The expense of the Armstrong guns and projectiles is very great, and the fact of their delicacy, and the inability of the guns to fire any but their own carefully prepared shot, might prove a serious disadvantage in war. At Sebastopol, for instance, where we picked up and refired the Russian shot, had our guns been Armstrongs, and the Russians been armed with rifled pieces grooved in accordance with their present plan, they could have easily dovetailed a little lead into the rear of the Armstrongs and refired them; whereas the fine grooves of our guns would have been ruined by re-using their own refired projectiles, and could not have returned a single Russian shot.

Broadside Naval Guns.

Turn we now to ships where the space is confined, and different sizes of shot and different charges have to be provided. What a dilemma poor Jack would be in with two different kinds of ordnance on the lower deck

and three on the upper! Why, in the hurry of action, he would be putting the square shot into the round holes, and the round shot into the square holes. I ask any man who has been on a ship's deck in action to say what does or does not take place. When men are stirred up by the excitement of action they are not able to attend to niceties. I can even speak of the "hurry" which is displayed in the practice on a field-day in the "Excellent," where I have been more than once the sponger or loader of the officers' gun. And what must be the case in a close hand-to-hand fight!

One of the great advantages of rifling, viz. that of enabling a molten-iron shell of very large capacity to be fired in safety, will also be lost. This advantage has been lately overlooked, as the Armstrongs appear unsuited for the purpose; and it cannot, therefore, cause much surprise that, because the loose-fitting round shells of small capacity have produced so little effect from smooth bores, the dangerous hot shot are again talked of as an arm for future use. I trust, however, that they will be given up.

The comparison so often made between round balls and rifled shot, is seldom if ever made as respects their comparative cost and their value at close quarters, but only as respects their effect at distances too great to be correctly measured, or to produce any decisive result in actual warfare. The question, as regards naval ordnance, is not, however, between the round ball and the elongated shell, for the round ball is the most effective, and is far more easily handled and loaded at close quarters, and the rifle shell is the best for bombardment; but between a mode of rifling that *will* admit of the use of the round ball at close quarters, and one that will *not* admit of its use. By adopting the former plan, good broadside guns throughout would be obtained for the decisive struggle,* and this is the first and the main point to secure, and the cost of ammunition would be kept at its old rate; by the latter plan, the broadside power would be lessened, a mixture of different sorts of weapons rendered necessary, and the simplicity essential in naval warfare entirely lost. I need not dwell upon the expense of the ammunition for such finely-grooved guns, nor the doubts about its keeping serviceable in the warm and moist atmosphere of a tropical climate; but I wish to remark, that the guns themselves are so delicate, that the powder cartridges of the 40 and 25-pounders are made up round pasteboard cylinders; and that the fouling, which occasions extra strain on the gun and stripping of the projectile, can only be prevented by the use of a wad composed of various perishable ingredients.

* The 68lb. round ball will perform more work than the Armstrong shot at probably less than a third the strain upon the gun; and a properly rifled wrought-iron piece would send its flat-headed shot with a shell base to burst inside the 4½-inch plates. Such a gun would also fire the round ball, and, when requisite, could use the heavy charges necessary to give a very high velocity in perfect safety. A very high velocity seems to produce an effect far beyond what the formula velocity $^2 \times$ weight gives; and if the generally received rule—that the resistance of armour plates is as the squares of their thickness—be correct, then at 200 yards the actual work done by the 68-pounders is double that of the Armstrong 110-pounders, when both shot are of cast-iron, and fired with 16lbs. and 14lbs. of powder respectively. This result is to be attributed to there not being sufficient time for the particles of iron round the part struck to properly aid in supporting it; and hence, if a much higher velocity can be obtained, and which I think will be the case, we may yet find that strengthened or wrought-iron 68-pounders will send their round balls—but certainly short flat-fronted elongated projectiles—through any target hitherto constructed.—R. A. E. S.

SKETCHES.

Segmental Sections of Comm.r Scotts Centrical Rifling.

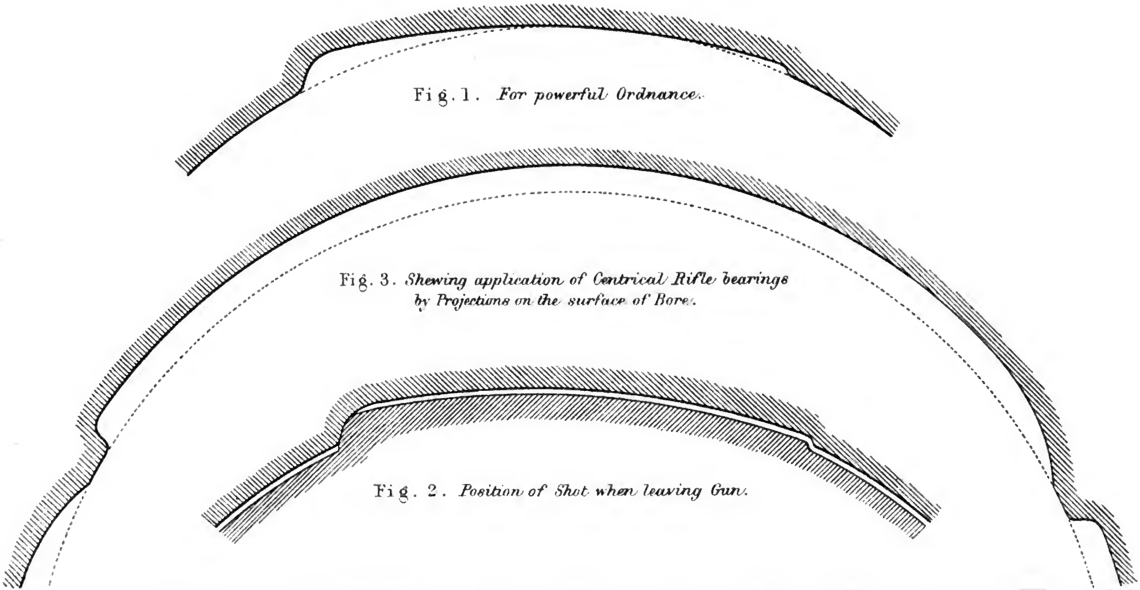


Fig. 1. *For powerful Ordnance.*

Fig. 3. *Shewing application of Centrical Rifle bearings by Projections on the surface of Bore.*

Fig. 2. *Position of Shot when leaving Gun.*

J.R. Jobbins.

These difficulties are the result of the fine grooves and the compression system, which, as is well known, is fast destroying the larger Armstrong guns; and although the new 70-pounder is to have a wider groove of altered shape, and a muzzle swell, little advantage will be gained.

Rifling with Plain or with Centrical Grooves.

Were, however, the leaded projectiles and fine grooves to be given up, and any plain groove and a simple iron projectile adopted, these difficulties would be obviated, and a much higher velocity obtained without straining the piece. It is true, that the result might not appear so favourable in target practice, but this could also be met by taking the plan of grooving, which I have already advocated before this Institution, (see Journal, vol. v. p. 437,) and which from its form is very easily sponged, and centres the projectile without jar, while its peculiar curve yields all the accuracy attainable by any known system (Plate III. fig. 1.) Hitherto the plan has not been carried out with great exactness, having been only applied to a cast-iron service 32-pounder gun, to which the projectiles were not fitted with precision; yet, with these disadvantages, and the gun weakened as it was by the rifling (for which it had never been intended), that plan gave an accuracy which was stated to be "good," and a range which at 2° was considerably greater than that of the Armstrong 100-pounder. It has also stood 310 rounds at various *elevations*, although a bad flaw existed in the bore.* The chief peculiarity of the system consists in shoulders for the projectile to glide easily out upon; and as it rests upon three bearings each from 5 to 12 inches long on the long axis of the shot (for shot from 5 to 12 inches in diameter), with a surface-breadth nearly equal to the depth of the rifle grooves (see Plate III. fig. 2), the amount of wear is truly inappreciable. Like the system of De Beaulieu, I confidently expect it will ultimately come to the front; and my only fear is that some inventor, with a longer purse than I have, perceiving the value of my concentric system, may, by some slight modification, gain the ear of those who control these matters and rob me of my labours. It would be easy, for instance, to turn my grooving inside out, and obtain results similar in kind, but in less perfection. You will see that such a figure as this (Plate III. fig. 3) will effect the purpose; but, though Sir W. Armstrong was recently in doubt whether the rib or the groove belonged properly to the bore, I have myself a strong opinion that a rib in such a situation would render even *his* recent composite wad inefficacious, and reduce the gun to the standard of a mere target weapon.

Of such plans we have had enough—they must fail in warfare; for although it is well to be enabled by exact fitting to fire with great accuracy, it is still more important for a weapon not to be rendered useless when this great nicety cannot be observed; or when, as at Sebastopol, on the top of a hill, any kind of shot are most thankfully received. We should, therefore, as suggested in my lecture previously alluded to, while aiming at making really powerful guns, with from 8 to 10 inches or greater

*** The muzzle of this gun will be shown in Class 11 in the International Exhibition, together with one of its (seven times) re-fired shells.—R. A. E. S.**

diameter of bore—guns which will project their shot with a very high velocity, and consequently flat trajectory, within fighting distances—bear in mind, that heavy charges strain the gun in projecting the rifle shot with a velocity which is readily attained by the round ball; and therefore that the power given by rifling should be added to that of the smooth bore, instead of the latter's being sacrificed to it.

English and French Rifled Guns: their different Nomenclature.

In the facility of using round shot, or adapting almost any sort of shell to its use, consists the value of the French system, and it is also extremely simple and inexpensive; and, even supposing that their guns could not with perfect safety fire more than one or two hundred rounds with elongated projectiles, the French would still have effected a great change at a trifling cost, for they have rifled their 30 and 50-pounders, so as to preserve the round ball and all the old ammunition, and have enabled these guns to discharge, in addition, projectiles, of which that fired from the 50-pounder has a larger diameter than, and probably contains as large a charge as, the Armstrong 100lb. shell.

While, therefore, we have been expending large sums, aiming at obtaining guns which shall be good rifles only, omitting the more important quality of smashing power at close quarters, the French first secured the easily managed round ball, and then added to its effect the advantages of the rifle projectile, in one gun; they have also suppressed varieties of calibres, and in the "Gloire" have carried out this simplification by arming her with 38 rifled 50-pounders; and, unlike our nomenclature, which places the Armstrong 40 above the French 30-pounder, which fires a 60lb. shell, containing more than double the powder charge, they still call their guns by the old names of 30 and 50-pounders: a difference that in the event of hostilities would at least detract from the merit that might otherwise be obtained, were an Englishman armed with the 40-pounder Armstrong to capture an enemy with guns of such very superior power as the French 30-pounders. In fact, with the exception of the 100-pounder, there is no finely-grooved weapon that could produce much effect against even a wooden ship, for the small hole which the shot would make, if they did penetrate, would be a very trifling matter; and the powder charge of the shells of the 40 and 25-pounders is too small to produce any great damage. And thus having endeavoured to indicate the progress of ordnance at home, and to show the value of our rifled guns, I have only to add, that the county owes a debt of gratitude, and something more substantial, to those gentlemen, who, although the service has no claim upon them, have given up years of their time, and incurred much anxiety and expense, in working out a problem so difficult and of such great national importance.

Captain Blakely.—It is rather late to commence a discussion, and I can add but little to the information which Captain Scott has been so kind as to give us on the subject. I would not like the meeting to suppose from what has been said that the French are satisfied with their guns standing only 200 or 300 rounds. On the contrary, they did not cease

their trials until they had fired some of their 32-pounders which had been strengthened, a thousand times, with the full charge of powder and three shot. They then fired one, 3,000 rounds with a single charge of powder and a single shot. So that they are pretty well off. The Spaniards have strengthened their gun—the old 32-pounder. They have tried several different ways of strengthening them. They did not know that there was any law; they did not know the proper difference of diameter to give between the hoops and the cast-iron gun. They had to find this out. They have been very liberal in publishing to the world the exact details of all these experiments, and they had a very good gun to commence with.

They began by making the hoops a little too tight, and the same in every other particular, and they found the gun did not stand so well. They then tried a little larger hoop, until they found out what the exact law was; and the last gun, now used in the Spanish Navy, has been fired 1,367 times with 8lb. of powder and a 62lb. shell. So I think they are furnished with a weapon which at all events is not liable to burst and injure their gunners.

Lieutenant Windus, H.M.I.N., asked whether some trials were not about to take place with the Belgian gun, that had been mentioned, with elongated shot, instead of spherical.

Captain Scott.—Yes; the Belgians have had guns made of Bessemer steel, a metal which they are inclined to adopt. They tested one gun, and it stood an extraordinary number of rounds. There is a clear report upon the subject in Fairbarn's last work on Iron. The leaded shot was taken by ourselves, as well as by other nations, at an early date, because we did not then perfectly understand rifling, and did not know how the iron shot could be shaped so as to truly centre in the bore. The plan of now making a shot cut its passage through the grooves is a great waste of power, especially when you can so easily shape the projectile to the rifling. Fitting is a mechanical operation, in which the English excel. I point this out, because I think we are going in a wrong direction in continuing to manufacture lead-coated shot. They will decay from damp, and those in store are decaying and the lead exfoliating. Many of you are aware that Lord Clyde sent home some bullets which could not be got down into the rifles at all. The lead had exfoliated, and the bullets were too large, and at Delhi several of our men were shot down while trying to force the bullets down the bore of their rifles.

The Chairman proposed the usual vote of thanks to Captain Scott for his valuable paper.

ARMSTRONG BREECH-LOADING 12 PR.

REPORT OF EXPERIMENTAL PRACTICE.

SHOEBURYNESS, 2nd April, 1861.

Height of axis of Gun above plane, $3\frac{1}{2}$ feet.

Ordnance . . Nature, ARMSTRONG'S B. L. 12 pr. Gun, No. 6. — Barometer, 29·7. Wind, South—3.

	cwt.	qrs.	lbs.
Weight	8	2	11

Length . . . . . . $7\frac{1}{2}$ feet.
Diameter of bore . . 3 inches.
Spiral, if rifled, 1 turn in 38 calibres.
Grooves, Number 38. Width, 0·15 inches. Depth, 0·05 inches.

Nature and object of the experiment—To ascertain the Range, &c., of Armstrong's Breech-loading 12 Pr. Iron Gun, in comparison with Whitworth's Breech-loading 12 Pr.

Programme received 28th March. Stores received, 2nd April, 1861. Minute No. 3625.

No. of Rounds.	Charge.	Elevation.	Recoil.	Projectile.			Times and Mean Time of Flight	Range, 1st graze.	Mean Range, 1st graze.	Deflection.			REMARKS.
				Nature.	Weight and Mean Weight.	Windage in inches.				Correction allowed for.	Left.	Right.	
	lbs.	deg.	Feet.		lbs. mean.		sends.	yds.	yds.		yds.	yds.	
1	1·75	2	8·0	Armstrong's Strong Shot.	12	Nil.	3·5	1239	—	Nil.	$4\frac{3}{5}$	—	3rd April.
2	—	—	7·10		—	—	3·7	1271	—	—	$6\frac{3}{5}$	—	
3	—	—	8·0		—	—	3·6	1238	—	—	6	—	
4	—	—	8·0		—	—	3·7	1307	—	—	4	—	
5	—	—	8·0		—	—	3·6	1226	1256	—	$4\frac{3}{5}$	—	
6	1·5	—	7·0		—	—	3·4	1108	—	—	$5\frac{1}{5}$	—	
7	—	—	7·0		—	—	3·4	1133	—	—	5	—	
8	—	—	7·0		—	—	3·6	1150	—	—	$4\frac{1}{5}$	—	
9	—	—	7·0		—	—	3·4	1121	—	—	3	—	
10	—	—	7·0		—	—	3·3	1137	1130	—	$3\frac{1}{5}$	—	
11	1·5	5	6·9		—	—	6·8	2134	—	—	11	—	2nd April.
12	—	—	6·8		—	—	6·9	2165	—	—	9	—	
13	—	—	6·6		—	—	6·6	2157	—	—	$8\frac{3}{5}$	—	
14	—	—	6·6		—	—	6·8	2146	—	—	$10\frac{1}{5}$	—	
15	—	—	6·6		—	—	6·8	2128	2146	—	7	—	
16	1·75	—	7·9		—	—	7·2	2357	—	—	13	—	Wind increased to 4.
17	—	—	8·0		—	—	7·3	2331	—	—	$11\frac{1}{5}$	—	
18	—	—	7·10		—	—	7·2	2356	—	—	11	—	
19	—	—	8·0		—	—	7·4	2351	—	—	$11\frac{3}{5}$	—	
20	—	—	8·0		—	—	7·3	2399	2360	—	11	—	
21	1·5	10	4·6		12	—	12·2	3512	—	—	12	—	Wind changed and
22	—	—	4·8		—	—	12·4	3576	—	—	11	—	increased. Squally.
23	—	—	4·6		—	—	—	3593	—	—	17	—	
24	—	—	4·6		—	—	12·4	3597	—	—	12	—	Wind increased to 6, and
25	—	—	4·5		—	—	12·2	3563	3568	—	11	—	continued squally.
26	1·75	—	5·0		—	—	12·8	3943	—	—	8	—	
27	—	—	5·0		—	—	12·8	3898	—	—	23	—	
28	—	—	5·0		—	—	13·0	3961	—	—	14	—	
29	—	—	5·1		—	—	13·0	3866	—	—	19	—	
30	—	—	5.1		—	—	13·0	3873	3908	—	21	—	

Elevation throughout by Quadrant.

The Gun was mounted on a Travelling Carriage, and placed on one of Lieutenant-Colonel Clerk's Platforms, on the level.

Wads, choked in the Cartridge, were used throughout the Practice.

(Signed) A. J. TAYLOR, Colonel R.A.,
Commandant and Superintendent.

The Secretary,
Ordnance Select Committee.

WHITWORTH BREECH-LOADING 12 PR.

No. 1. REPORT OF EXPERIMENTAL PRACTICE.

SHOEBURYNESS, 2nd April, 1861.

Height of axis of Gun above plane, $3\frac{1}{2}$ feet.

Ordnance . . Nature, WHITWORTH'S B. L. 12 Pr. Gun, No. 1.

	cwt.	qrs.	lbs.
Weight	9	3	0

Length . . . . . . $8\frac{8}{12}$ feet.
Diameter of Bore, Major axis 3 in., Minor 2·75 in.
Spiral, if rifled, 1 turn in 55 inches.
Grooves, Number . Width, . Depth,

Barometer, 29·7
Wind, South—3.

Nature and object of the Experiment—To ascertain the range, &c., of Whitworth's Breech-loading 12 Pr. Iron gun, in comparison with Armstrong's Breech-loading 12 Pr.

Programme received 28th March. Stores received 2nd April. Minute No. 3625.

No. of Rounds.	Charge.	Elevation.	Recoil.	Projectile. Nature.	Projectile. Weight and Mean Weight.	Projectile. Windage in inches.	Times and Mean Time of Flight	Range, 1st graze.	Mean Range, 1st graze.	Deflection. Correction allowed for.	Deflection. Left.	Deflection. Right.	REMARKS.
	lbs.	deg.	Feet.		lbs. mean.		scnds.	yds.	yds.		yds.	yds.	
1	1·75	2	7·0	Solid Shot—Hexagonal shaped.	12·004	—	3·5	1266	—	Nil.	$\frac{1}{3}$	—	3rd April.
2	—	—	7·3		—	—	3·6	1344	—	—	—	3	
3	—	—	7·6		—	—	3·4	1250	—	—	—	2	
4	—	—	7·3		—	—	3·4	1280	—	—	—	1	
5	—	—	7·6		—	—	3·4	1306	1290	—	—	$1\frac{1}{3}$	
6	1·5	—	6·6		—	—	3·6	1223	—	—	—	$2\frac{1}{3}$	
7	—	—	6·6		—	—	3·6	1211	—	—	—	$1\frac{1}{3}$	
8	—	—	6·6		—	—	3·4	1188	—	—	—	2	
9	—	—	6·6		—	—	3·5	1209	—	—	0	0	
10	—	—	6·6		—	—	3·4	1159	1198	—	—	$1\frac{1}{3}$	
11	1·5	5	6·0		—	—	7·2	2442	—	—	$1\frac{1}{3}$	—	2nd April.
12	—	—	6·0		—	—	6·2	2072	—	—	—	2	
* 13	—	—	6·0		—	—	6·8	2389	—	—	—	$\frac{1}{3}$	
14	—	—	5·10		—	—	7·2	2449	—	—	—	2	
15	—	—	6·0		—	—	7·2	2486	2368	—	1	—	
16	1·75	—	7·0		—	—	7·0	2475	—	—	$2\frac{1}{3}$	—	Wind increased to 4.
17	—	—	7·0		—	—	7·2	2644	—	—	1	—	
18	—	—	6·9		—	—	6·9	2335	—	—	2	—	
19	—	—	7·0		—	—	7·0	2370	—	—	$1\frac{1}{3}$	—	
20	—	—	7·0		—	—	7·2	2533	2471	—	$2\frac{1}{8}$	—	
21	1·75	10	6·9		—	—	13·2	4409	—	—	4	—	Wind changed and increased. Squally.
22	—	—	6·8		—	—	13·0	4348	—	—	10	—	
23	—	—	6·8		—	—	12·8	4387	—	—	$7\frac{2}{3}$	—	
24	—	—	6·9		—	—	13·0	4405	—	—	$8\frac{2}{3}$	—	Wind increased to 6, and continued squally.
25	—	—	6·9		—	—	13·4	4449	4400	—	4	—	
* 26	1·5	—	5·0		—	—	12·6	4137	—	—	4	—	
27	—	—	5·6		—	—	12·9	4299	—	—	3	—	
28	—	—	5·0		—	—	1·0	4139	—	—	$2\frac{1}{8}$	—	
29	—	—	5·0		—	—	12·8	4318	—	—	$3\frac{1}{3}$	—	
30	—	—	5·0		—	—	12·8	4220	4223	—	2	—	

Elevation throughout by Quadrant.

The Gun was mounted on a Travelling Carriage, and placed on one of Lieutenant-Colonel Clerk's Platforms, on the level.

The Powder and Wad were contained in the usual Tin Cases.

The rounds marked * were fired with Tin Cases that had been used previously, there being no more in store, and they were simply well cleaned, and answered quite as well as when new.

The Wad weighs about 2 oz. 4 drs., and the empty Tin Case about 8 oz. 8 drs.

(Signed) A. J. TAYLOR, Colonel R.A.,
Commandant and Superintendent.

The Secretary,
Ordnance Select Committee.

Official Reports, as extracted from the excerpt Minutes of Proceedings of the Institution of Civil Engineers.—ED.

Friday, January 17th, 1862.

Captain Sir F. E. NICOLSON, R.N. C.B. in the Chair.

LIFEBOATS.

By Captain J. R. WARD, R.N.

I.—*Preliminary Remarks.*

In a country bounded on all sides by the sea, whose earliest associations are connected with it, through the medium of which it has derived its civilisation, its wealth, its grand political status, and probably to a great extent the energy, enterprise, and indomitable spirit of its inhabitants;—in a country whose almost innumerable ships ceaselessly traverse every sea, and are harboured in well nigh every port on the globe we inhabit;—and, above all, in a country whose shores in every winter's storm are strewn with the wrecks of its ships and the corpses of its sailors;—in such a country it may well be presumed that an instrument devised to save the helpless castaway from an untimely end will be an object of general interest.

Such an instrument is a lifeboat ! I feel therefore under no other embarrassment in offering some explanations on its character and specialities than that which arises from the fear lest I should not do justice to so important a subject.

As it is a subject not very generally understood, it will be necessary to go into some details that will be familiar to many present, whose indulgence I have therefore to ask.

I propose, successively, to explain the general principles on which lifeboats are constructed as compared with other boats; the peculiar properties of the principal descriptions of lifeboats now in use on the coasts of the United Kingdom; the character of their equipment; and the system under which they are provided and managed in this country, especially those belonging to that noble institution to which I have the privilege and happiness to be attached—the National Lifeboat Institution.

II.—*Distinctions between Ordinary Boats and Lifeboats.—Properties of Lifeboats: Extra buoyancy, self-discharge of water, stability, self-righting, internal capacity, speed, weight, strength of build, material, &c.*

Although the word lifeboat has not in itself any definite meaning, it is pretty generally understood as signifying a boat especially constructed for saving lives in storms and heavy seas; when ordinary open boats could not attempt to do so, except at the imminent peril or certain destruction of those within them.

What then are the causes which make ordinary open boats unsafe in rough seas? And in what manner are those causes removed in lifeboats?

The principal causes of a common open boat being unsafe in a heavy broken sea are its liability to fill with water and swamp from a wave breaking into it, or by its upsetting, and loss of stability from all water within it falling to one side with every motion of the boat. It is therefore obvious that the chief requirement of a lifeboat is the counteraction, as far as possible, of these defects.

Extra Buoyancy.—The first essential property then in a lifeboat is what is termed extra buoyancy; which property is in a greater or less degree common to all lifeboats, excepting to some of the so-called lifeboats, which, to meet the requirement of a loosely-worded clause in an Act of Parliament, are placed on the decks or hoisted up to the sides of many of our merchant vessels.

Extra buoyancy may intelligibly be defined as the excess of floating property in any body immersed in a fluid, the expression of which in pounds indicates the number of pounds weight of any other body that it is capable of floating in addition to itself. Thus a log of fir timber, the specific gravity of which wood is about half that of water, will float with only half its body immersed, the remaining half representing its extra buoyancy. A piece of dry fir wood has therefore extra buoyancy about equivalent to its own weight.

This important property in a lifeboat should be sufficient in amount to enable it to be loaded with people, and nearly filled with water, without its then being so deeply immersed as to be unmanageable.

Extra buoyancy in all our coast lifeboats is now chiefly obtained by occupying a sufficient portion of the interior with enclosed water-tight compartments or boxes. These compartments by being placed along the sides of a boat, and at its extreme ends, are made to serve the further purpose of adding to stability, by confining all water that may be shipped to the central part of the boat, where it is in some boats made to perform the office of ballast.

The mode in which this property is applied to the different descriptions of lifeboats will be best explained by diagrams and models.

In Plate I. representing transverse sections of the five principal descriptions of lifeboats in use in this country, the air-tight compartments which form the extra buoyancy are marked A.

It will be observed that in figures 1, 2, and 3, this extra buoyancy occupies a large portion of the interior of the several boats, so that if filled with water they would evidently still float buoyantly; whilst fig. 4 represents a section of a tubular boat, which, having no interior corresponding with that of an ordinary shaped boat, can contain no water. Fig. 5 is a section of one of Whyte's ship's lifeboats. It has not so much extra buoyancy as figures 1, 2, and 3, but has sufficient for an ordinary ship's lifeboat.

By the proper application of this principle, we have then not only an insubmergible boat, but the possession of other valuable properties, which are so mingled with it as to make it difficult to separate the one from the other. Thus, as in figures 1, 2, 3, and 5, by occupying the interior space along the sides of a boat with air-tight compartments, the water within her is, in varying degrees, prevented from falling over to the lower side; and lateral stability in a rough sea is thereby much increased. Again, as shown in figures 1 and 3, by placing the greater part of the extra buoyancy beneath a water-tight deck, means are provided for self-discharge of all water falling into the boat above the deck, through the instrumentality of connecting tubes between that part and the open sea below.

And again, as in fig. 2, by attaching large buoyant wales, or fenders, or pads, as they are variously termed, round the exterior sides of a boat, both lateral buoyancy and resistance to sudden heeling over, and thereby lateral stability, are increased.

Lastly, by occupying the extremities at bow and stern with enclosed air-compartments, the properties of self-righting and longitudinal stability are provided.

Self-discharge of Water.—Since however, notwithstanding great extra buoyancy, it would be inconvenient and unsafe for so large a quantity of water to remain in a boat as often falls into one from a single broken sea or surf, another requisite property is at once apparent, viz. that of self-discharge or self-relief of water. Indeed, without this property, the full advantage of that of extra buoyancy is not realised, as without it all water breaking into a boat must remain in her, and become a shifting cargo, settling more or less on one side or at one end with her every motion.

Having then already the property of extra buoyancy, nothing more is needed, in order to effect the self-discharge of all water above the level of the outside sea, than to have a sufficient number of open holes in the bottom of the boat. Through such openings all water shipped from above must then pass out by its own gravitation, until lowered to the outside level.

In some descriptions of lifeboats, as in figs. 1 and 3, self-relief of water is total, unless they are very heavily laden with passengers or other weights; in others, as in fig. 2, it is only partial, a large quantity of water below the outside level remaining in the central part of the boat, where it serves as ballast.

In figures 1 and 3, the watertight deck before alluded to, which is there shown by the line B, forms the inside floor of the boat; it is laid with considerable sheer, *i.e.* curved upwards at bow and stern, so that all water over it should settle to its central part. Between this central part of the

Pl. 1.

Fig. 1.

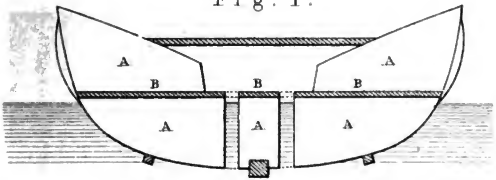


Fig. 2.

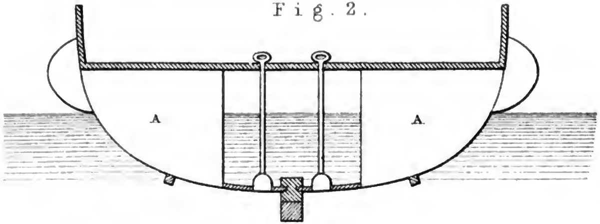


Fig. 3.

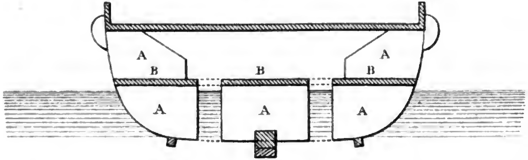


Fig. 4.

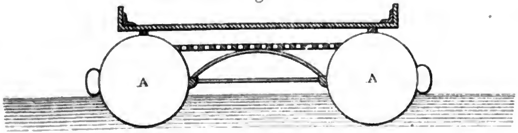
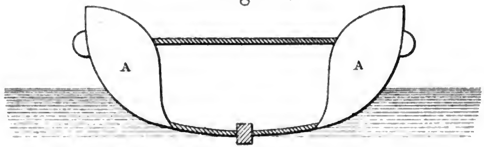


Fig. 5.



deck and the floor of the boat below, passing through the intermediate space, tubes of metal are fixed, varying in size and number in different boats, and open at both ends; thus opening passages between the space above the deck and the sea below the boat, but excluding all communication with the space between the deck and the floor—just as a chimney open at both ends passes from a groundfloor to the exterior of a building above the roof through intermediate apartments, whilst excluding communication with them.

These tubes vary in size, from 3 to 6 inches in diameter. The smaller they are, the more are required. As a single wave breaking into a boat will often fill her to the thwarts, there should be a sufficient number of relieving tubes to clear her of that quantity in twenty or thirty seconds. These relieving tubes in all the old classes of boats, as above stated, are open at both ends, and therefore freely admit the ingress of water from below, as of its egress through them from above. To remedy this defect, which is not an unimportant one in some boats, an ingenious self-acting valve has been invented, which valves are fitted in all the lifeboats on the plan of the National Lifeboat Institution. It is a simple plate, fitting the tube at its upper end, and made to turn on an axis on one side of its centre, as does an eccentric wheel. It is so balanced as of itself to remain shut, and on the slightest pressure of water from below, to shut still closer, whilst, on water falling on it from above, the pressure on the larger division of the plate, being necessarily greater than on the smaller, opens it downwards. Valves, unless self-acting, and of very simple construction, are objectionable; but these are found to answer admirably, and some which have been ten years in use are still efficient, and have never got out of order.

In the Norfolk and Suffolk water-ballasted lifeboats, fig. 2, Plates I. and II. which have no decks, there are merely holes in the floor, with large plugs to them. There are two of these holes, with corresponding plugs, at every thwart. The plugs have long handles, similar to those of common spades, so that the men sitting on the thwarts can insert or withdraw them at pleasure. Being large powerful sailing boats, and very heavy, it is a great convenience to be able to handle them on the shore without the weight of the larger portion of their ballast. They are therefore launched empty; but as soon as they are clear of the beech, and before entering the heavier part of the surf, the plugs are withdrawn, and the water admitted until it rises to the outside level. The water thus let in varies in amount from four to seven tons in different boats. Through the open holes the water within, after a sea being shipped, will always subside to the level of the outside water, all below that level remaining as a constant quantity. In some lifeboats, as in fig. 5, and in all other ships' lifeboats now in use, no provision is made for the relief of water except by baling. It must be acknowledged that all such boats are without one of the most requisite qualities of a good lifeboat.

In the tubular lifeboat (fig. 4) it will be seen that this property is attained in the greatest perfection, as, having no open interior, no water can lodge within her.

Stability.—The next quality of essential importance is lateral stability, or resistance to upsetting sideways. Stability may be obtained by three modes: 1st. By great breadth of beam; 2nd. By occupying the interior

with air cases, as described already, in such a manner as to leave no space for water to remain in the interior, into whatever position the boat may be thrown, or to so confine it to her central part that it cannot fall much to one side above the centre of buoyancy; 3rd. By ballast. There is a limit to the application of each of these modes, which requires careful consideration. 1st. Great breadth of beam, in proportion to length, is a certain mode of securing great stability, but it adds to weight, above the centre of buoyancy, and by increasing the area of the "midship section" entails loss of speed, requiring proportionally greater propelling power. It also prevents the application of another important property—that of self-righting, in the event of being upset.

The widest rowing lifeboats are those of the North Country, or Greathead plan (fig. 1, Plate I.), some of which have $10\frac{1}{2}$ and 11 feet beam to 30 feet length. The Norfolk and Suffolk boats (fig. 2) have also great beam, the largest having 12 feet to 46 feet length; they are, however, exclusively sailing boats.

In sailing boats, increase of beam can be very well given, as greater power of propulsion can be obtained by enlarged sails; but in rowing-boats this power can only be had by using longer oars, with two men to each, which thereby incurs the risk of an unnecessary number of lives. In one of such boats twenty-two men out of a crew of twenty-four perished at Shields by her being upset in the year 1850.

2nd. A most valuable means of adding to the stability of a lifeboat, as intimated under the last heading, is by occupying its sides with buoyant cases. By an examination of Plate II. the relative properties of different lifeboats in this respect will be readily perceived. It will be noticed that the North Country lifeboat (fig. 1) is possessed of this property to the fullest extent; as, if thrown over with one gunwale to the water's edge, there will only be space for a very small quantity of water to lie in her at the level of the outside sea, and that little but slightly on one side of the centre of gravity.

The continuation of the side air-cases to the gunwales, as in those boats, is, however, in another respect detrimental, by occupying space which is valuable for the stowage of wrecked persons.

In fig. 2 a greater quantity of water is retained, but the larger portion of it is on the windward or higher side of the centre of buoyancy, where it serves the purpose of ballast, and thereby adds to the stability of the boat.

In fig. 3 there is space for a larger quantity of water, some sacrifice of this important quality being made, to enable the scarcely less valuable property of self-righting to be brought into play, which great side buoyancy, placed high, would prevent.

In fig. 4 it is evident that no water can remain in any position.

In fig. 5 a large quantity of water might lie on one side of the centre of buoyancy, but the loss of stability arising therefrom is counteracted by large side buoyancy, placed high.

Ballast.—There remains the third principle of stability, ballast. Ballast may be either solid or liquid. Solid ballast is most frequently applied, in the shape of an iron keel, in which position, at the lowest part of a boat, it acts with the most powerful leverage. Iron keels in lifeboats vary from

3 to 17 cwt. Ballast formed of wood, and of cork enclosed in water-tight cases, is also used in the self-righting lifeboats of the National Lifeboat Institution, of nearly equal weight to the iron keel. Thus a 10-oared boat 32 feet long has an iron keel of 9 cwt. and nearly the same weight of wood, or of cases of cork stowed beneath the deck.

It is difficult to some persons to imagine that wood or cork can partake of the nature of ballast. In fact, however, any substance heavier than air may be used as ballast, a pound of cork being as much ballast as a pound of iron or lead. The advantage of employing a ballast of less specific gravity than water is that, in the event of a boat being stove in and the spaces below the deck filling with water, the extra-buoyancy of the material then comes into play, and prevents the boat from becoming so deeply immersed as to become unmanageable.

In February, 1858, the National Lifeboat Institution's lifeboat at Youghal, in Co. Cork, in launching got stove on a rock and a hole was made in her floor as large as a man's head; she became at once much more deeply immersed, and the water rose to 5 or 6 inches above her deck, the spaces beneath it having filled with water. Nevertheless she proceeded on her mission of mercy, her gallant crew rowed her two miles to a wrecked Austrian ship, and in the midst of a very high surf, which frequently broke over and filled her, she took fourteen men from off the vessel's bowsprit and conveyed them safely to the land. Had all her ballast been of metal she would, undoubtedly, have become so deeply immersed after being stove that she could not have proceeded to the wreck, and all those poor men would have perished.

As, however, a large quantity of fixed ballast causes great extra labour and difficulty in land transport and launching, water ballast is occasionally employed. It is sometimes enclosed in water-tight tanks, but more frequently, as in the Norfolk and Suffolk boats, is unconfined.

In consequence of the liability of enclosed tanks to leak from decay or injury, and of the water thereby spreading over the whole floor of the boat, water ballast has been discontinued in most rowing lifeboats. I am however of opinion that, if properly applied and secured, it would be free from any risk, and might often be employed with much advantage.

With the exception of three or four of the old boats on the North Country plan, which still retain water tanks, the only boats in the United Kingdom now ballasted with water are the Norfolk and Suffolk boats, fig. 2, already alluded to.

These latter boats deserve especial notice. They are only eleven in number, nine of them being exclusively sailing boats varying from 39 to 46 feet in length, and from 10½ to 12 feet in breadth.

As they are unmanageable in a heavy sea under oars, and as they have often to work to windward against the heaviest gales to the rescue of the crews of vessels wrecked on the numerous outlying banks which exist off that part of the coast, it is indispensable that they should be heavily ballasted, and have considerable draught of water, to give them good weatherly qualities. In order, then, to make this requisite provision, without involving too much weight for convenient launching, they are provided with water ballast, in addition to having iron keels. This water is let in by the same apertures that serve for self-relief of water, the plugs

which close them not being withdrawn until the boat has got off the beach. The water thus let in is of very large amount, being in the largest boat of this class not less than seven tons—which water is not retained in an enclosed tank, but left to fill up every unoccupied space up to the level of the plane of flotation. By the representation of a cross-section of one of these boats in fig. 3, Plate I., it will be seen that this unocccupied space is chiefly confined to a narrow channel of about one-third of the boat's width. Cross air-cases at bow and stern, to the level of the thwarts, also confine it lengthwise. The average area of these channels is about 20 feet long by 4 feet wide, in which the water lies to an average depth of $2\frac{1}{2}$ feet, in amount equal to about 200 cubic feet, or $5\frac{3}{4}$ tons.

A large quantity of water also settles between the large timbers of these boats, beneath the side and end air-cases, which cases are moveable separate boxes, and cannot be made to fit so closely as to fill up these spaces. These boats have also iron keels varying from 12 to 17 cwt.

At first thought it would appear highly dangerous to have so large a quantity of water loose within a boat; the truth is, however, that the safety of the principle consists in the largeness of the quantity, taken together with the circumstance of its being cut off from access to the ends and sides of the boat. If these boats were less heavily ballasted, they would be more lively, rising and falling with every motion of the sea, and the water within them would be constantly in motion towards the lowest level; but thus heavily weighted, and propelled by powerful sails, they cut deeply through every sea instead of rising to it—they, in nautical phraseology, make much worse weather of it than a lighter and more lively boat would do; heavy bodies of "green sea" break over them so as sometimes to altogether submerge their crews, and to hurl them from one end of the boat to the other; but their stability is so great that their crews have unbounded confidence in them, and they are protected against being washed overboard by "ridge ropes" rove through iron staunchions round the boat, fixed in the gunwales.

The only boat of this class which has ever upset was the Southwold lifeboat in February, 1858, the then most recently constructed boat of the class. She was taken out, through a rather high surf, for the quarterly exercise of her crew. On returning to shore, before entering the surf, the crew injudiciously inserted the plugs and pumped out about two-thirds of the water ballast. They then ran her under sail, with too much way, into the surf, when, a sea overtaking her, threw her stern up; the ton-and-a-half of water still in her then rushed to the bow, which became completely submerged, and, broaching to across the surf, she immediately upset; her masts broke off on coming in contact with the ground, and not being a self-righting boat she remained keel up. Her crew of 15 men all having on their life-belts, in accordance with the rules of the National Lifeboat Institution, were saved; but three gentlemen who had gone off as amateurs, and had refused to put on life-belts which had been offered to them, were drowned, although one at least of them was known to be a good swimmer. Had this boat been full ballasted, the sea would probably have broken over the stern instead of lifting it, and the accident would not then have occurred.

In this lifeboat, in consequence of the crew having withdrawn their

confidence from her after the accident, and as they also thought she floated too deeply in the water, the water-ballast channel was at my suggestion filled in with portable solid blocks of fir timber up to the level of the former water-ballast, she being thus provided with fixed ballast of half the weight of the former water. Since that alteration she has given every satisfaction to her crew. I have thought this circumstance deserving of mention, since the question as to the relative merits of water and solid ballast will, I have no doubt, continue to be a disputed one.

Although, however, this principle of ballasting with a large quantity of unconfined water has on the whole answered well in the large sailing boats above referred to, I consider it to be inapplicable to rowing boats, which, being of smaller size, and only slowly propelled against high surfs, would be liable to be thrown so much out of a horizontal position as to cause the water to settle at one end, as in the Southwold boat, and thereby endanger upsetting. I feel sure that I have many times been through heavy surfs in the self-righting rowing lifeboats of the National Lifeboat Institution, which would have proved fatal to any rowing boat so ballasted. It is also a serious drawback to such boats that their crews, whilst rowing, must sit with their feet in the water, which, in a protracted service in cold weather, cannot but be very trying to them.

Self-righting.—I come now to the explanation of a property which, by comparison, is a novel one, although more than two-thirds of the lifeboats in the United Kingdom are now provided with it,—a property the value of which has been disputed by many, and for the adoption of which in its lifeboats the National Lifeboat Institution has been accused by some of pursuing a phantom. I allude to the property of self-righting, by which the self-return of a boat to its normal position, after being upset, is effected.

Previous to the year 1852 no self-righting lifeboat existed, although the power to make a boat self-right was ascertained by experiment, and recommended for use by the Rev. James Bremner, in the year 1792.

That which led to its first practical application was the offer, by his Grace the Duke of Northumberland, of a prize of 100*l.* for the best model of a lifeboat, in the year 1850, consequent on the upsetting of one of the Shields lifeboats, and the drowning of twenty-two out of twenty-four men, who formed her crew, to which I have already alluded.

In a statement addressed on that occasion to the boatbuilders of the United Kingdom, by a committee nominated by his Grace, the different qualities to which a certain value would be attached were named, and amongst them was included that of self-righting, which property was possessed by the boat to which the prize was subsequently awarded.

I shall, under another heading, have more particularly to refer to the circumstances attending, and the results following, the Duke of Northumberland's philanthropic offer, so will not now break the thread of a progressive definition of the properties of existing lifeboats. A most mistaken notion has not uncommonly prevailed amongst those who have not studied the subject, that the property of self-righting was merely a strong tendency to revolve in the water, just as a floating cask if set in motion on its axis will complete several entire revolutions round the same before it will stop, and that therefore in the same ratio that a boat is made to

possess the property of self-righting must she also have a tendency to upset. This hypothesis is no "Frankenstein" of my own, but one which I have had several times to disprove with a serious countenance.

I think I shall be able to make it clear that the real difference between an ordinary and a self-righting boat is, that whilst the former, on being thrown by a sea or other force on one side beyond a certain angle, offers no further resistance, and cannot return; the latter, on the contrary, continues to oppose such a force in every position in which it can be placed, unless nicely balanced with its keel exactly above the centres of gravity and motion, or, in nautical *parlance*, "keel up," a position in which it could not even momentarily remain in a rough sea.

The only familiar object that occurs to me which will serve as an illustration of the principle, is one of those children's toys called "tumblers," which, into whatever position you may force or throw it, will most obstinately self-right, and certainly show no disposition to revolve on its centre, or even to make a second "somersault" without a second application of physical force. This quality of the child's toy is precisely the same as that in operation in the self-righting lifeboat.

To obtain this peculiar property in a boat, all that is required is to attach to her a heavy iron keel, or otherwise ballast her heavily; to give her a fair sheer of gunwale; and to enclose a portion of her bow and stern as watertight air-chambers, as shown in the models on the table. The amount of ballast and the size of the air-chambers are of course matters for careful calculation.

The manner in which the desired effect is produced will be at once perceived on examination of the drawing or model of one of these boats. The bow and stern air-chambers having sufficient buoyancy to support the whole weight of the boat when keel up, she is then floating unsteadily on two points, with the heavy iron keel or other ballast carried in an elevated position above the centre of buoyancy, thus forming, in mechanical language, an unstable equilibrium, in which dilemma the boat cannot remain—the raised weight falls to the one side or the other of the centre of gravity and drags the boat round to her ordinary position, when the water shipped during the evolution quickly escapes through the relieving tubes, and, those of her crew who have been thrown out of her regaining her, she is again ready for any service that may be required of her.

The National Lifeboat Institution was, at an early period, warned by opponents to the system, that the self-righting of a boat would prove useless, inasmuch as that it would rarely happen that those upset from her could regain her or again get into her. Facts have since proved the invalidity of these prognostications, as these boats have upset and their crews *have* regained them and again got into them, whilst the crews of other lifeboats which have upset have perished.

Notwithstanding this manifest advantage, it might still be questionable if any other important principle should be sacrificed to effect it. But, if it can be shown that it can be introduced without any such sacrifice, it would surely be reprehensible in those who employ others on so dangerous a service as the rescue of shipwrecked persons, not to provide them with this additional means of safety.

Without blinking the question I will at once point out how far any sacrifice has been made to secure the self-righting property.

Its requirements are :—

1. Ballast.
2. Enclosed air-chambers at bow and stern placed sufficiently above the centre of gravity.
3. Limited breadth of beam.
4. Limited side buoyancy.

1. *Ballast.*—Now the first of these requirements, ballast, is a positive source of safety. It necessarily increases lateral stability, and by adding to the weight of a boat gives a greater momentum when rowing against a high broken sea; which is often a source of safety, as she may thereby pass safely through or over a sea, instead of being driven astern by it. From the same cause also, she can be more readily held back, and be prevented from "running" on a sea when returning to the shore, which is one of the greatest dangers that a boat can encounter.

2. *Raised Air-Chambers.*—The second requirement, raised air buoyancy at bow and stern, is a great source of safety, by preventing all water or other weights from settling at either extreme end of a boat, and also by preventing much water from breaking over the bow or stern.

It will be readily conceived how advantageous it must be, on a heavy sea breaking over the bow of a boat, to have a buoyant power equivalent to more than a ton weight instantly resisting submersion. I have myself been too many times in the bows of the boats of the National Lifeboat Institution, in heavy surfs, not to have learned to appreciate the advantage. I believe also, from my personal observation of them, that, placed under the same circumstances, one of the North Country lifeboats would take half-a-ton of water into the bow from a single surf, where a good self-righting boat would scarcely ship a bucket-full.

3. *Limited Beam.*—I admit that great breadth of beam is a source of safety, as giving increased stability, and that some sacrifice of beam is required for self-righting. But great breadth of beam involves loss of propulsion against a heavy sea, which is often loss of safety, and requires the use of longer oars with more men to work them, all which are disadvantages. A self-righting boat with limited beam (say one-fourth of length) has, therefore, the advantage over the wider boat in these respects, whilst the loss of stability from diminished beam is made up for by an equivalent stability derived from ballast.

4. *Limited Side-buoyancy.*—I grant that some sacrifice of stability is made by a reduction of side-buoyancy, but it is the only real sacrifice, and is, I think, more than made up for by the gain of the self-righting power.

A further comparison of the relative advantages of righting and non-righting boats will come more regularly under a special heading devoted to a review of the existing lifeboats in the United Kingdom.

Internal Capacity.—Another quality in a lifeboat on which some stress has been laid is, what is termed "internal capacity," *i.e.* the amount of unoccupied space within a boat which might be filled with water on the breaking into her of a sea. The amount of "internal capacity" is determined by that of another property already considered. Given a certain amount of "extra buoyancy," and the remaining space still unenclosed

constitutes what is usually implied by internal capacity. Practically, however, internal capacity is only that amount of space in which water will remain in a boat when lying on one side, with one gunwale only awash; for, if a boat should be absolutely filled to the level of the gunwales by a surf (a thing which I have never seen myself, and which I suspect is of very rare occurrence, unless in one of the deep, water-laden Norfolk lifeboats), the first motion of the sea would throw the greatest portion of it over one side; the small quantity that would then remain in her, and of which her discharging tubes would not relieve her, as shown in figures 1, 2, and 3 (Plate II.), is then in reality an index of her internal capacity.

Speed and Weight.—After the properties already explained, and which may be more especially termed the safety properties of a lifeboat, the next in importance is speed; for there would manifestly be no utility in providing the safest contrivance for taking off the crew of a wrecked vessel if it could not be propelled to her in time to be of service. Frequently indeed, as stated in a former paragraph, speed constitutes safety, as the slow boat may be carried back by a heavy sea, and up-ended, or turned athwart, when the faster boat would have quickly passed through and over the danger. To obtain speed, or frequently any progressive motion, against a heavy sea—I speak of rowing-boats—fine lines and especially sharpness of bow are necessary, as in an ordinary boat, and that not at the waterline only, but carried up quite to the stem-head, which is immersed by every heavy surf which it meets. So also lightness, which is an advantage in smooth water, is an obstacle against a head-surf, when the momentum of greater weight without increased bulk is required to carry the boat through the moments of sudden resistance from the successive blows of heavy seas; just as the momentum of the familiar "flywheel" is required in many common machines to continue and equalise motion, as in turning a wheel by a crank. The greater the length of a boat in proportion to area of midship section, weight being the same, the greater will be her momentum, and the faster will she be propelled against a head sea. The proportion of four feet of length to one foot of width of midship section is that which is now being adopted by the National Lifeboat Institution in its double-banked rowing-boats. In its single-banked boats, which are stationed at places where larger and heavier boats could not be managed, still less proportional width is given.

The preceding are all the important properties that have to be considered in a lifeboat, although there are certain other conditions that follow as a matter of course; such, for instance, as sufficient roominess for stowage of a considerable number of wrecked persons, and for the rowers to use their oars with advantage; and great strength of build, to be qualified to stand the violent shocks which such boats must sometimes sustain from collision with wrecked vessels or contact with the shore.

In connection with this last-named condition, I may here state that most of the old classes of lifeboats are clinker or clench built, of oak wood. The self-righting boats of the Institution are built of fir, on the diagonal principle, which mode of build affords great strength and elasticity. The tubular boat of Mr. Richardson is made of tinned iron.

Having explained the especial properties required to be possessed by

Fig. 1.

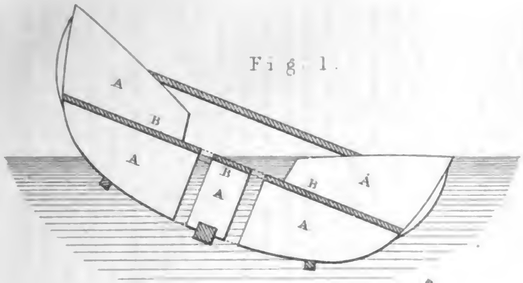


Fig. 2.

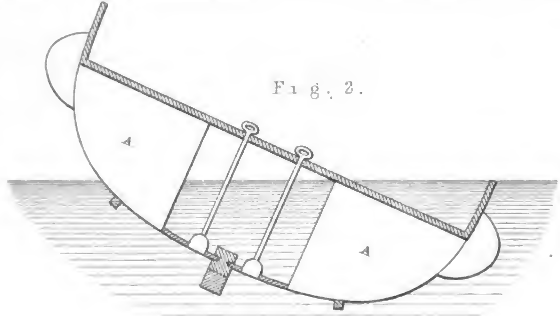


Fig. 3.

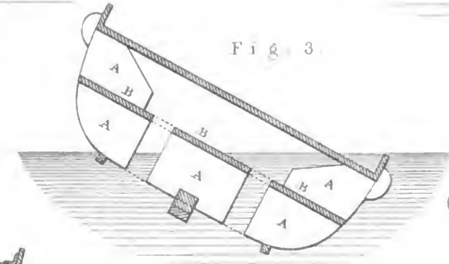


Fig. 4.

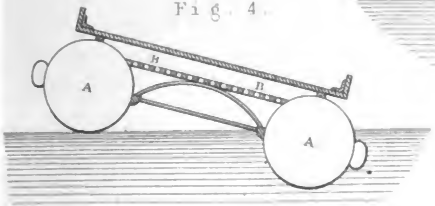
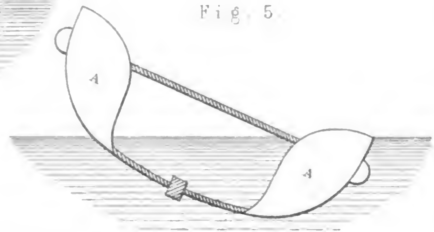


Fig. 5.



J R Jobbins

lifeboats, I will briefly state the peculiarities of the principal existing boats, and the history of each, and offer an opinion on their relative merits so far as I have had opportunity for judging of the same. I may first, however, observe, that one of the great obstacles to improvement in lifeboats has been, that opportunities have not existed for comparing, one with another, their several qualities. Each boat has been known in its own locality by its own crew, who have been unacquainted with any other. However indifferent as compared with others might be her qualities, if she has been fortunate and met with no accident, she will in general have won the entire confidence of the local boatmen, who will think there is no other boat equal to her.

So also the builders and designers of lifeboats have had no opportunity to test their own by comparison with others: such experiments are too costly to be attempted by individuals, for, independently of the great cost of a good lifeboat (rarely less than 200*l.*) the expense of its removal from place to place to be brought into contact with other boats, and of its care whilst waiting favourable opportunities of trial, would be considerable; whilst the great cost of making such trials, which the local boatmen would never undertake, for any private persons, in a sufficiently rough sea to be of value, without very large remuneration, would alone be sufficient to deter most persons from incurring the same; especially as the whole might be thrown away if the boat should after all turn out worthless. Again! supposing such a boat were to upset and drown several of her crew when out for trial, who would undertake the support of their widows and orphans?

I have alluded to these difficulties to shew how few persons can be qualified to give a practical opinion on the relative merits of lifeboats, although it is not uncommon to hear inventors or partizans of particular descriptions of boats pronounce dogmatically as to their superiority to all others.

Having now held the office of Inspector of Lifeboats to the National Lifeboat Institution 10 years, and on my periodical rounds on the coasts of the United Kingdom having not only had opportunities for examining and learning the "local character" of every lifeboat in the kingdom, but also for going afloat several hundred times in lifeboats, and often in the heaviest surfs, I have necessarily some experience of them. I could nevertheless wish that it were greater, especially as regards the older classes of boats, which, being less numerous than the newer self-righting boats, and mostly not belonging to the Institution, I have had fewer opportunities for testing in heavy surfs—I give my opinion, however, for as much as it is worth.

III.—*Review of existing Lifeboats.*

1. *North Country Lifeboat. Plate I. fig.* 1.—This Lifeboat is commonly called the "Greathead" boat, as a Mr. Henry Greathead, boat-builder, of South Shields, who built the first boat of the class, in the year 1789, was the reputed inventor of it. Since, however, a Mr. William Wouldhave always asserted that he was really the original designer of it, although he had not the means of building a boat from his design, I have preferred

calling it the North Country Boat—a considerable number of boats, all more or less derived from it, having been placed on the east coast of Scotland, and of England north of the Humber. There are now eighteen of this class of boats on the coasts of the United Kingdom. They mostly belong to harbour and dock corporations, and to local lifeboat associations at trading ports on our north-eastern coast, Shields, Sunderland, and Hartlepool being the chief. The oldest lifeboat now existing is of this class. She was built in 1802. She is stationed at Redcar in Yorkshire, and is now the property of the National Lifeboat Institution. As no accident has ever happened to her, the Redcar boatmen have unbounded confidence in her, and would not exchange her for any other boat that could be given to them.

These boats have undoubted advantages: their great breadth and the exclusion of all water from their sides give them much stability, and their great curvature of floor and keel enables them to be turned more quickly to meet a sea, and to run more safely before a surf than a straight keeled sharp-bowed boat can do. These peculiarities of form are, however, unfavourable to speed, and cause them to steer wildly.

This is the earliest description of lifeboat of which we have knowledge. The largest of the class is rowed by 12, the smallest by 8 oars, double banked. They are neither provided with sails or rudders, being exclusively rowing boats, their great curvature of keel *(vide models)* unfitting them for sailing, and the boatmen preferring to steer them with two long oars at the stern, by the use of which they can turn a boat much more quickly to meet a sea than with a rudder, especially when she has but little way on her, which must always be the case when rowing against a heavy sea and gale. Notwithstanding their great stability, several of these boats have upset from time to time, occasioning the loss of many lives. They cannot be made to self-right after upsetting, and they ship much more sea than do the self-righting boats. On the whole I much prefer the latter to them.

2. *The Norfolk and Suffolk Sailing Lifeboats. Fig.* 2.—Of the lifeboats now in use, those next in antiquity are the Norfolk and Suffolk sailing lifeboats. The oldest of which we have any knowledge was one recently condemned at Great Yarmouth, which was built in 1833.

These are splendid boats for the especial use for which they are required—viz., as sailing boats to proceed to wrecks ashore on outlying banks, and not being required for closer service, which would need to be performed under oars. As exclusively sailing boats, I believe them to be unequalled. Yet, from various causes, there is perhaps scarcely any other part of the coast for which they would be useful, unless on Deal beach, for service on the Goodwin Sands.

I have never myself had an opportunity for going out in one of these boats in a very high sea ; but the services performed by the crews of some of them have been noble, especially by those at Lowestoft and Pakefield, in Suffolk, and at Caistor, in Norfolk. As rowing lifeboats, I have, under another heading, stated that I think them unsuitable.

3. *The Self-righting Lifeboats of the National Lifeboat Institution.*—Previous to the year 1852 all the lifeboats in the United Kingdom were modifications of one or the other of the two classes of boats just described,

excepting four or five on a plan, now obsolete, invented by Mr. Plenty, a coachbuilder in Berkshire, and the Liverpool lifeboats. These latter were simply fine powerful boats, having a large portion of their interior occupied with empty casks as extra buoyancy, but not provided with any means for self-discharge of water.

Under the head of *Self-righting* I have already stated that in the year 1850 His Grace the Duke of Northumberland offered a prize of 100*l.* for the best model of a lifeboat. In response to that offer no less than 280 models and plans of lifeboats were submitted. They were deposited at Somerset House, where they went through a long series of examinations and tests by a committee, ably presided over by Captain Washington, R.N., and of which James Peake, Esq., the present master shipwright of Devonport Dockyard, was a member. The task that this committee had to perform was a most onerous and difficult one. Here were before them a very large number of plans, the selection from which was a matter, it might be, involving the life or death of many hundreds, perhaps even, looking to the future results of their decision, of thousands of individuals. Yet I believe that no member of the committee had ever been afloat in a lifeboat in a high surf, and Captain Washington was the only one who had had an opportunity for examining any large number of the lifeboats on the coasts. I think that that committee were entitled to the greatest credit for undertaking such a responsible and laborious duty, and for the judicious manner in which they carried it out.

Having decided on the various qualities which a lifeboat ought to possess, they appropriated to each quality certain numbers proportionate to its importance, the total of all the numbers amounting to 100. To each design was then appropriated, after careful deliberation, the proportion of numbers on each quality to which it appeared entitled. To the design possessing the largest total of numbers it was decided to award the prize of 100*l.*, to which was added, by his Grace, another 100*l.* towards the cost of a full-sized boat on the selected plan. The prize was awarded by the Committee to Mr. James Beeching, boat-builder at Great Yarmouth.

A large boat, 36 feet long, and rowing 12 oars, was built from this design, which boat was afterwards purchased by the Ramsgate Harbour Commissioners, and a model of which is now on the table. An improvement in the mode of ballasting her was subsequently made, and since that time she has been one of the most frequently used and useful lifeboats in the United Kingdom. Some of the most gallant exploits performed by her crew will be familiar to many present through the medium of recent numbers of "MacMillan's Magazine." This was the first self-righting lifeboat.

The committee did not, however, propose the adoption of this boat, but deputed their member Mr. Peake to furnish a design for a lifeboat which should, to the best of his judgment, combine all the good qualities of the best of the designs that had been sent in. This was done, and a Report of the whole proceedings of the committee prepared, with drawings of the "prize-boat," and of several others to which high numbers had been awarded, as also the design furnished by Mr. Peake. The whole together, with other useful information on the subject, forming a handsome volume, was published at the expense of the Duke of Northumberland, and gratui-

tously presented by him to the competitors for the prize, and many others.

A boat from Mr. Peake's design was then built at Her Majesty's dockyard at Woolwich, by direction of the Lords of the Admiralty, as a compliment, I believe, to the Duke of Northumberland. After a long series of trials, and after undergoing many alterations, this boat was completed and presented to his Grace, who had three others built similar to it at his own expense, and one on Beeching's design, with boathouses and transporting carriages complete, for the use of the fishing stations on the coast of Northumberland.

After these boats had been tested on the coast, by myself, in high surfs, the National Lifeboat Institution proceeded to build others on the same plan, although cautiously at first; which plan, with but slight modification and some improvement in form, it has continued to adopt up to the present time. It now possesses no less than one hundred self-righting boats, on this plan.

This boat has been called "Peake's Lifeboat;" it would, however, with more propriety be called "Beeching's Lifeboat, improved by Mr. Peake," or "The Northumberland Prize Lifeboat improved by Mr. Peake," it being a nearer resemblance to Beeching's prize-boat than to Mr. Peake's design as published in the "Northumberland Report" before alluded to.

Unfortunately, soon after the award of the prize to Mr. Beeching, accidents happened to three of his boats, which wellnigh smothered them altogether, and brought the very principle of self-righting, for a time, into disrepute. One of the requirements selected by the prize committee to which numbers were to be appropriated was lightness for land-transport; to meet which Mr. Beeching and several others, knowing that weight was required when afloat, adopted water-ballast, to be let in at the moment of launching. This ballast Mr. Beeching unfortunately did not secure properly, and three of the first boats built by him for another society upset through the leaking out of their water-ballast, when on their experimental trials with large sails set. From want of their ballast they did not self-right, and unhappily on two of those occasions lives were lost.

The self-righting principle was now at a discount, and many who from the first looked on it as the whimsical offspring of a theorist's brain, fit only to contend with storms on Utopian shores, now fully believed that the young visionary had already closed its earthly career. But its nurses thought otherwise, and, satisfied of its practical reality and vigorous growth, were noways disheartened, so, setting it again on its legs, they sent it forth to make its own way and prove its own worth. It has now a ten years' existence, and is certainly, as yet, shewing no signs of premature decay.

Since, as I have thought it just to shew that the sole authorship of the self-righting lifeboat now in use belongs neither to Mr. Peake nor Mr. Beeching, I have here designated it the "Self-righting Lifeboat of the National Lifeboat Institution."

Now it is not pretended that this boat is infallible—that it cannot be upset—or that it cannot be improved on. I fully believe that no boat can be built which will not be liable to upset under some circumstances. But, after going afloat in these boats numberless times in heavy surfs and being exactly acquainted with their character, I do not hesitate to give the

opinion that, taking them altogether, they are, as rowing boats, more suited for the service for which they are required, and safer to those who man them, than any other description of boat in use. In continuing to adopt this class of boat in preference to any other, the Institution has not been influenced by my reports of them alone, but by the encomiums of the crews who work them; by the noble services they have rendered to shipwrecked persons; by their numberless successes and few failures; and by the results of the few accidents which have happened to them.

Since their first adoption, six of these boats have been upset and one put *hors de combat:* four of that number being a small class of single-banked boat, rowing but six oars, which are placed at stations where there are not local means for managing the larger double-banked boats.

IV.—*Accidents to Lifeboats.*

These accidents were as follows:—

1st. *Lyme Regis.*—On the 7th January, 1854, the Lyme Regis lifeboat was upset by the falling over of a French schooner upon her, the schooner's deck cargo of casks of wine being dashed with violence into the boat. Although this boat was seriously damaged, and was for a time held down by the vessel's sails so that she could not self-right, she was righted after the sails and gear which held her down were cut away, and the crew of the French vessel and the boat's crew were safely carried to shore by her, with the exception of one of the latter, who had unfortunately untied his lifebelt, and was last seen struggling amongst the *debris* of the wreck. Had the boat not been a self-righting one, all hands would undoubtedly have perished, the accident happening at a considerable distance from the land.

2nd. *Dungeness.*—On the 19th October, 1858, in the middle of the night, the small six-oared Dungeness lifeboat upset, by broaching to when running through a heavy surf on her return from a deserted wreck. Her crew, eight in number, were thrown into the water, but she instantly righted again, when they all got into her and returned in her safely to shore, reporting themselves to the officer of coastguard at the station as ready to go out in her again at any moment their services might be required.

3rd. *Aldborough.*—On the 3rd of January, 1860, the Aldborough lifeboat was hauling off the beach by an anchor and warp to proceed to a stranded vessel when a tremendous surf struck her, tore the warp out of the hands of the crew who were hauling her off, and upset her. Fifteen men were in her, of whom fourteen were thrown into the sea and one remained in the boat, clinging to a thwart.

The masts, which were up, broke off on coming in contact with the ground, and the boat directly righted again. Some of the crew were thrown 30 yards or more from the boat by the sea which upset her. Four of them made for the shore; the other ten returned to the boat. Unfortunately the weather was so intensely cold, the snow being a foot deep at the time, that, although the crew supported by their lifebelts were able to regain the boat, their blood was so chilled and their limbs so paralysed,

that they could not unaided get into her again. The one man who had gone round with her, and who was not even entirely wet through, aided nine men into the boat, but the tenth man was by that time so benumbed with cold that, finding himself unable to retain his grasp of the life-lines round the boat with his hands, he seized one of them between his teeth. Sad to say, however, before the man within the boat was able to assist him, a heavy lurch of the boat tore his teeth from the jaw and he was carried away. Two of the four men who had made for the shore were with difficulty rescued from the breakers on the beach, but the two others and the poor man with the broken jaw perished from cold. Supported by their lifebelts, the bodies were swept by the tide to the north, within a short distance of the shore, and followed by a large crowd of persons; but when at last they were got to the beach, a mile northward of the site of the accident, life was extinct.

4*th. Ardmore, Ireland.*—On the 6th of November, 1860, the Ardmore small six-oared lifeboat when out for exercise was returning to the shore through a very high surf, when, too much way having been given to her, she ran on a sea, broached-to, and upset. Her crew of eight men, with three amateurs, one of them the local honorary secretary, were thrown into the sea, but she self-righted, and they all regained her, and returned safely to the shore.

5*th. Tramore, Ireland.*—On the 17th February, 1861, the Tramore six-oared lifeboat, when attempting to save the crew of a wrecked vessel, was upset, and her crew, eight in number, were thrown out of her; she directly self-righted, and a portion of them got into her again; the remainder swam to the shore supported by their belts. She afterwards saved some of the wrecked men, and a few days after saved the crew of another wrecked vessel.

6*th. Calais.*—On the 28th February, 1859, the small six-oared lifeboat which had been presented to the town of Calais by the English government, got stove-in alongside a stranded steamer off Calais; becoming partially filled with water, her stability was thereby injured, and those who got into her from the steamer, all getting to her further side, from fear of injury by her striking against the vessel, her off gunwale was put under water, and, a sea breaking over it at the time, she upset; she righted again, but three out of seven persons who had got into her, and had on no lifebelts, unhappily perished. A mixed crew of English and French, and great mismanagement throughout, occasioned this accident.

7*th. Scarborough.*—On the 3rd November, 1861, the Scarborough, 32 feet ten-oared self-righting lifeboat, which had been only a few weeks on her station, was proceeding to a wrecked vessel, stranded very close to the shore, when she got into a very high and irregular surf, caused by the rebound of the waves from a sea-wall. Her motion became so violent that the steersman was thrown overboard, and the crew, in attempting to save him, got into a still worse position, and, some of their oars getting broken and knocked out of their hands, she became unmanageable, and was dashed several times with terrific violence against the sea-wall, her crew being all thrown out of her in succession. This accident is of so recent a date that the circumstances of it will be fresh in the memory of every one; the newspapers having recorded all its details. It will suffice, therefore, to

state that, to the astonishment of all present, the boat did not upset, and was not broken to pieces; that one of her crew was crushed between the boat and the wall, which caused his death; and that one was drowned, he being the only one who had unfortunately neglected to put on his lifebelt.

The above are the only serious accidents that have occurred to this class of boats; for those to the first experimental and immatured lifeboats of Mr. Beaching cannot be fairly included in the category.

The result of the seven accidents above enumerated are, that out of 82 persons who were in the boats when the accidents occurred to them only 9 perished; 3 from cold, 2 from injury, and 4 from drowning through not having on lifebelts. Now, had not these boats been self-righting, and had not their crews been supplied with good lifebelts, how much larger a number would indubitably have perished!

As a contrast, we have, during the last eleven years only, the upsetting of the Shields lifeboat in 1849, with the loss of 20 out of 24 of her crew. On the 4th January, 1857, the upsetting of the Point of Ayr lifeboat, on the Liverpool plan, when her whole crew of 13 men perished. And, lastly, the upsetting, on the 9th February, 1861, of the Whitby lifeboat, when 12 out of 13 of her crew perished. Giving a total of 45 lives lost, out of 50, by these three accidents alone.

With such an extraordinary contrast in the results of accidents to self-righting and non-righting lifeboats, who will venture to say that the principle of self-righting is a chimera, or that it is any other than a great practical and valuable truth?

No less than 135 of these self-righting lifeboats have been built during the last ten years by the Messrs. Forrest, of Limehouse, builders to the Institution, of which number 30 have been for foreign governments or for our colonial and foreign possessions. They have, during the same period, saved several hundred lives on our own coasts, and have rendered other valuable services to wrecked vessels.

4. *Richardson's Tubular Lifeboat.*—The next coast lifeboat to be described is "the tubular." By the model of this boat, which is on the table, it will be seen that it is altogether different in principle to any other boat; consisting of two long tubes running parallel to each other a few feet apart, having their ends turned upwards and inwards, and terminating in points, with an open-work or grating deck with corresponding thwarts, all supported above the tubes.

The boat of which this is a model was built in 1852 by Messrs. H. and H. T. Richardson, two Welsh gentlemen, father and son. They had for many years had a small boat of the same class in use on a lake in Wales, and, when the Duke of Northumberland offered the prize for the best design of a lifeboat in 1850, they sent the model, which is now on the table, to compete for it. With much public spirit they then built at Manchester a full-sized boat, 40 feet long, and rowing 14 oars, and made a coasting voyage in it themselves from Liverpool to the Thames, putting into most of the intermediate ports. In a half-comic, half-serious, account which they published of this voyage, under the title of "The Cruize of the Challenger," she was described as having encountered extraordinary dangers, and displayed marvellous properties. Her designers further chal-

lenged all the lifeboats in the kingdom to compete with her. But, as I have stated under a previous heading, there are almost insuperable difficulties in the way of competitive trials of lifeboats. As it was, I believe these gentlemen spent considerably more than 1,000*l.* in the building and exhibiting of this boat, yet they were unable to obtain any trial of her in competition with other lifeboats.

I should myself much like to see a competitive trial of the different descriptions of coast lifeboats, including this one, in a gale of wind and heavy surf, but such a trial could only be undertaken by the Government. It would have to come off at some large port, such as Shields, where plenty of boatmen acquainted with lifeboat work would be available, and where, from the contiguity of lifeboat stations, some boats could be got together without much difficulty or other expense than the payment of men for trying them. Still, the tubular at least would have to be expressly built for the trial and to be sent from a distance, so that I doubt if the whole trial, which, to be conclusive, might have to be more than once repeated, could be gone through at a less cost than 1,000*l.*; and even then there might be great difficulty in procuring equally effective crews for all the boats, which would be essential. Again, it would be necessary, in the event of any lives being lost in such a series of trials, to secure a permanent provision for any widows and orphans who might be left, which could be done by Government alone.

The tubular lifeboat built by the Messrs. Richardson in 1851 was afterwards sold by them to the Portuguese Government, to be stationed at the city of Oporto, off the port of which there is a very dangerous bar.

Another somewhat smaller tubular boat was, in 1856, built for the National Lifeboat Institution, and stationed at Rhyl, the boatmen at which place had applied for such a boat. She has since that time saved several wrecked crews, and has been very highly reported on by those who work her. She has necessarily very great stability, and the advantage of instantaneously discharging all water that breaks over her. She also tows very steadily; but that is a quality not often brought into requisition.

The obstacles which have stood in the way of a further trial of these boats have been:—

1. The uncertainty of the boatmen on the coast taking to a boat so different from an ordinary one.

2. The uncertainty of their durability, and their liability to damage by collision with the ground, the material of which they are made being tinned iron, which is very easily indented or cut through.

3. Their requiring a very clumsy and heavy transporting carriage.

I have had no opportunity for going afloat in this boat in any very heavy surf, so can offer no practical opinion respecting her; but she rows faster in a moderate sea than I should have anticipated.

Should any further trials be made of this class of boat, it might be worth while to have one made of wood instead of metal tubing.

5. *Whyte's Lifeboat.*—The last description of lifeboat which I have to describe is that of the well-known yacht-builder Mr. Whyte of Cowes. This boat competed for the Northumberland prize in 1851 as Lamb and Whyte's lifeboat. It is mostly in use as a ship's lifeboat, chiefly on

board the vessels of some of the large steam-packet companies.* I believe it to be the best ship's lifeboat yet adopted; but as a coast lifeboat it is not considered to possess sufficient "extra buoyancy," or means for self-discharge of water; it has not, therefore, come into general use, although it is very fast both as a rowing and a sailing boat. There are only two lifeboat stations provided with it, and there are three others in the hands of the boatmen on the Kentish coast, where they are available to save lives as well as to serve their owner's purposes.

V.—*Modes of Propulsion.*

Having explained the general properties of lifeboats, as exemplified in those principally in use on the coasts of the united kingdom, the not uninteresting question arises as to what is the most advantageous mode of propelling them—I mean by manual labour; for, although for the performance of services at very long distances sails must be employed, and in a few localities where boats are stationed in harbours steam-vessels may be available to tow them, yet, as, at nine stations out of every ten, lifeboats have to be launched from an open, exposed, and generally flat beach through a heavy surf, and have to proceed entirely through broken water, the manual labour of their crews is the only possible mode of propelling them.

It would perhaps not have been worth while to moot this question at all, but that it happens to be one of the most favourite notions of inventors, and of even some scientific persons, that a lifeboat could be propelled more rapidly by revolving paddles or screws, worked by winches within the boat, than by oars.

Those who take up this notion too often forget the mechanical law, that by no possible arrangement or application of machinery or leverage can the power or strength of one individual person, or any other power, be really multiplied. They forget that, if by leverage or tackle-purchase an individual can be enabled to lift or drag a weight 100 times greater than by his unaided strength, he can only move the same through a hundredth part of the same space in a given time, and that what therefore is apparently gained in power is lost in time or speed.

The question then really at issue is, not—How shall the power of a boat's crew be multiplied? but—How can the actual power which they do possess be most advantageously applied?

A few minutes' consideration must, I am sure, convince any one, that, ancient as is the mode of propelling boats by oars, no more beautiful and convenient instrument than an oar could be devised for the purpose.

Undoubtedly, where great velocity as well as power can be obtained by extraordinary mechanical force, such as that of steam, the rotatory motion

* The Lords of the Admiralty have recently ordered a lifeboat on this plan to be provided for every man-of-war stationed on the west coast of Africa.

It is much to be desired that every ship of war should be provided with a good lifeboat. Many valuable lives, both of officers and men, have been lost for want of boats that could be safely lowered in a gale of wind at sea, or taken through a surf on the shore or bar of a river with impunity.

of the wheel has great advantages; but even as applied to the propulsion of large vessels by the ordinary paddles, or by the oblique blades commonly termed screws, great loss of power occurs when a vessel is subjected to much motion in a heavy sea, so that frequently no headway can be made; for in a paddle-steamer one paddle will be frequently revolving in the air and the other be too deeply immersed, whilst in a screw-vessel the blades will be often partially out of water and their force considerably diverge from a horizontal line.

But a lifeboat in a heavy surf is subjected to motion so much more violent and excessive in amount than a large vessel is liable to in an open sea, that, even if it were possible to work the former by steam, the loss of power would be so great as to stop all progress. What then could the much more limited power of ten or twelve men avail under the same circumstances, even if they were accustomed to exert those particular muscles which are brought into use in turning a rotatory machine?

The advantages of the oar are—

1st. That it is worked with less loss of power from friction by manual labour than would be any rotatory instrument.

2nd. That, in the hands of a skilful rower, it is always worked at full power; its blade, in obedience to the quick eye and steady hand, following the upheaving or downfalling wave, and, in measured time, cleaving its varied surface with the whole force of the broad chest and muscular arm directing it.

3rd. That, being in daily use by the coast boatmen in pursuing their own avocations, they are not only already skilled in its management, but have those particular muscles which are required to work it already strengthened by use.

In truth, this last reason alone for its preference is a sufficient reply to all advocates of the paddle or screw, and, consequently, my usual reply to inventors or others who suggest the employment of either of the latter is, that, if they can secure for us at each lifeboat station a corps of men whose daily work is that of turning winches, or grindstones, the question may then be open to consideration.

VI.—*Equipment.*

Having settled the principles on which a lifeboat should be constructed, and decided on the mode of propelling her, we have now to equip her for service. In doing so we have, as a first duty, to provide her with everything that can contribute to the safety of those whose lives we jeopardise by employing them on this dangerous service; secondly, to make her as far as possible independent of all assistance from wrecked vessels, the crews of which are often in a helpless state, perhaps lashed to the rigging, and unable to throw a rope, or even to get from the wreck to the boat without aid.

A lifeboat is therefore provided with lines, called life-lines, some festooned round her sides, by the aid of which any one in the water using them as stirrups can get into her; others with corks attached are thrown from within her when alongside a wreck, and float on the water all around her. She is also furnished with a cork lifebuoy, which, with a line

attached, can be thrown or floated to any one in the water who might be too distant to reach the life-lines of the boat. She has likewise strong but light lines with grappling-irons attached, one at the bow and another at the stern, which, by being thrown into the rigging or on board a wreck, fasten themselves, so that the boat can be at once held to the wreck without the assistance of any one in her. An anchor and cable; a good lantern for nightwork; a compass; and a drogue or water-bag, which is dragged behind a boat to prevent "broaching-to" when running before a heavy sea, are also necessary to a complete equipment; and last, but not least, is the supply of a good life-belt, or life-jacket as it is sometimes called, to each of the boat's crew.

As the life-belt is an especial hobby of my own, and as the description with which the boats' crews of the National Lifeboat Institution are provided was designed by myself, I trust I shall not be tempted to be wearisome to my hearers; but, since I consider the subject to be one of the utmost importance, I shall at some length remark on it.

One of the causes of the great loss of life which attended most lifeboat accidents in the olden time, independently of the boats not possessing the self-righting property, was undoubtedly that their crews were not provided with life-belts, or, as in the case of the late Whitby lifeboat, that those they had were of a worthless description.

The cases of accident which I have already quoted under the head of self-righting, are equally illustrative of the value of good life-belts, for, unless in each case the men had been supported by their belts, the self-righting property would have been of no service to many of them. For it must be remembered that the majority of our coast boatmen cannot swim, and that even the best swimmers forfeit their lives, when upset in heavy surfs, through losing their presence of mind. Many cases could be quoted, but none more conclusive than that of the Southwold boat before referred to, when three gentlemen without belts were drowned, although one of them was known to be a good swimmer, whilst 15 men having on belts, several of whom could not swim, were all saved. And again, that of the Whitby boat, when one man who had on a good belt, although unable to swim, was saved, whilst 12 who had on inferior ones were drowned. How many lives might be saved annually if one of these belts was provided for the master and each man in our merchant ships!

The requisite qualities of a lifeboatman's life-belt are—

1. Sufficient extra-buoyancy to support a man heavily clothed, with his head and shoulders above the water, or to enable him to support another person besides himself.

2. Perfect flexibility, so as to readily conform to the shape of the wearer.

3. A division into two zones, an upper and lower, so that between the two it may be secured tightly round the waist; for in no other manner can it be confined sufficiently close and secure round the body without such pressure over the chest and ribs as to materially affect the free action of the lungs, impede the muscular movement of the chest and arms, and thereby diminish the power of endurance of fatigue, which, in rowing boats, is a matter of vital importance.

4. Strength, durability, and non-liability to injury.

With the help of the different life-belts on the table, I hope to be able to

show that the cork belt designed by myself, and which is supplied to all the lifeboats' crews of the National Lifeboat Institution, possesses the first two qualities in a greater degree than any other life-belt, and the third one exclusively. (*Vide* fig. below.)

The belt I hold in my hand is one of this description. Its extra-buoyancy is equal to about 25 lbs. It will support an ordinary man, with his clothes on, with the shoulders and chest above the water. The most buoyant of the old descriptions of cork belt (Carte's) had extra-buoyancy equivalent to about 14 lbs. but many of them not more than 7 or 8 lbs. The largest size of the ordinary inflated belts has buoyancy equal to 20 lbs. when completely inflated; some not more than 8 or 10 lbs.

The defects of all inflated air-belts, are, their liability to puncture, want of strength, want of flexibility if more than half inflated, difficulty of inflation in very cold weather, and the liability of their inflating-valves to get out of order by corrosion from the effects of salt water. Some of these defects were partially remedied in an inflated belt designed by myself, in four compartments. This belt had extra-buoyancy equal to from 30 to 35 lbs.; so that, if two of its compartments were injured, the remaining two would suffice to support one person. But the insufficient strength of all belts of this class, and the difficulty of inflating them in cold weather, made it evident that an efficient life-belt was a desideratum yet unattained.

Up to that time (1854) there was no cork belt having sufficient buoyancy, or flexibility, or strength. The only solid cork belt was composed of a

single row of either rectangular blocks of cork sewn up in a cotton jean covering, or pads of cork-shavings or dust.

In that year, however, it fortunately occurred to me to attach narrow uncovered ribs of cork to a strong backing or broad belt, each piece being separately sewn on by strong twine, in such a manner that the breaking off of any one piece would not loosen that next to it, whilst one surface only of the corks being attached to the belt, afforded perfect flexibility. An examination of this belt cannot fail to convince any one that it possesses all the qualities already pointed out to be necessary, and that it has the further advantage of affording great protection to the body of the wearer.

Upwards of 3600 of these belts have now been issued, nearly half of which are at the lifeboat establishments of the National Lifeboat Institution. On the occasions of quarterly exercise in the summer months, the lifeboat men not uncommonly jump overboard to test the belts, and they have everywhere great confidence in them. After the fatal accident to the Whitby lifeboat, I was at Whitby, and questioned the only man who was saved, and who was the only one who had on one of these belts. I asked him if he had any difficulty, amongst the heavy surf, in keeping his feet down and his head well above the surface. In reply, he stated that after the first sea broke over him he found himself so quickly raised above the water again, that, although unable to swim, he entertained no doubt of his safety, and lost all fear.

There are other descriptions of life-belts on the table, which will show the different ideas on the subject that have occurred to different persons.

Transporting Carriage.

There is one other very important auxiliary to a lifeboat, which has to be noticed, viz. a carriage. Every lifeboat, except a few of the largest size, is provided with a carriage, on which she is kept in the boat-house ready for immediate transportation to the most favourable position for launching to a wreck. A lifeboat is thus made available for a greater extent of coast than she otherwise would be, and even when launched from abreast of the boat-house can be much quicker conveyed to the water's edge than she could be if not on a carriage. In addition to this ordinary use, a carriage is of immense service in launching a boat from a beach, to that extent indeed, that one can be readily launched from a carriage through a high surf, when without one she could not be got off the beach. An explanation of the manner in which this service is performed will be readily understood.

The lifeboat is drawn to the water's edge, where the carriage is turned round so that its rear end, from which the boat is launched, shall face to seaward. The crew then take their seats in the boat, each rower in his place with his oar over the side, and the coxswain at the helm or with the steering-oar in hand. The carriage is then backed by men or horses or both, sufficiently far into the water to ensure the boat being afloat when she is run off the carriage; or, if the ground be very soft, or sufficient help unobtainable, the carriage is first backed far enough into the water before the crew get into her. Self-detaching ropes, termed launching ropes, pre-

viously hooked to each side of the boat's sternpost, and rove through sheaves at the rear end of the carriage, are then led up the beach, and either manned by assistants or have one or more horses attached to them.

When all is ready, the coxswain, watching a favourable moment, gives the word, and the boat, the keel of which rests on small iron rollers, is run off rapidly into the water with her bow facing the surf. The oarsmen then give way, even before her stern has left the carriage, and she is at once under command, ere the sea has time to throw her back broadside to the shore, which is usually the effect of attempting to launch through a surf from an open beach without a carriage, unless a hauling-off warp attached to an anchor be permanently laid down outside the surf. This latter plan is only available in a few localities where there is a comparatively steep beach.

There are different descriptions of lifeboat carriages, but those which are now almost universally provided are on a plan designed by myself (Plate IV.), of which there is also a model on the table. It has advantages over any others that I am acquainted with: a chief peculiarity being that by detaching the fore-body the fore end of the keelway rests on the ground, forming a gradual incline up which the boat is hauled bow-foremost to replace her on the carriage, instead of hauling her up stern foremost at the rear end as in other carriages, the former arrangement being more convenient and less laborious.

A set of portable skids (Plate V.), one being fitted as a turn-table, on which the boat is hauled out of the water, before replacing her on her carriage, completes the usual equipment of a lifeboat. The boats of the National Life Boat Institution, and all belonging to them, are kept in roomy and substantial boathouses under lock and key, in charge of paid coxswains, under the general superintendence of local honorary committees of residents in the several localities.

VII.—*Review of the whole system of saving lives from Shipwreck on the Coasts of the United Kingdom.*

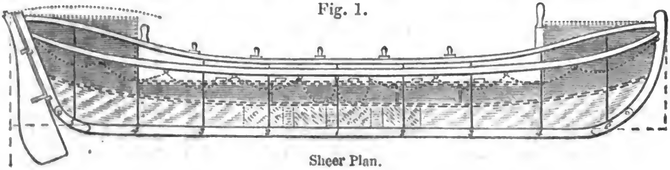
It now only remains to pass briefly in review the machinery which has been and is in use on the coasts of this great maritime country for the preservation of human lives from shipwreck; that is to say, the machinery expressly provided for that purpose.

Wrecked persons can be saved from the shore by two modes. They may be taken off a wreck by a lifeboat, or may be drawn to the shore along a rope conveyed to the wreck by the now well-known rocket and mortar life-saving apparatus. A model of the rocket apparatus in use may be seen in the Museum of this Institution. The provision of that apparatus on all those parts of the coast where it is likely to be useful is undertaken by the Board of Trade from the Mercantile Marine Fund, and placed under the management of the coast-guard. It is now kept in a most efficient state, the men being periodically practised in its use, and an average of about 300 lives are saved annually through its instrumentality. It is mostly useful at places where lifeboats cannot be stationed. Manby's Mortar and Dennett's Rocket apparatus have been in general use since the early part of the present century.

Plate III.

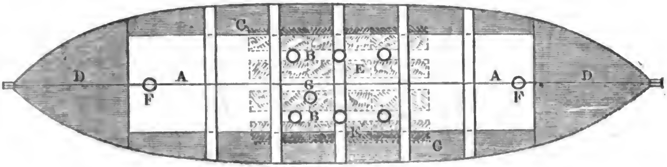
THE LIFEBOAT OF THE ROYAL NATIONAL LIFEBOAT INSTITUTION.

Fig. 1.



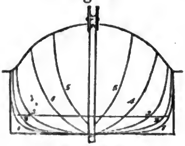
Sheer Plan.

Fig. 2.



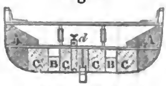
Deck Plan.

Fig. 3.



Body Plan.

Fig. 4.



Midship Section.

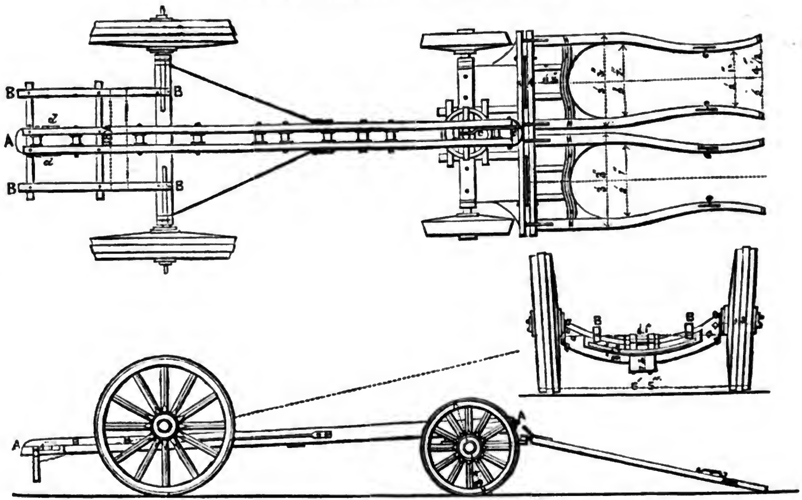
The accompanying figures show the general form, the nature of the fittings, and air-chambers of one of these boats, 33 feet in length and 8 feet in breadth. In figs. 1 and 2, the elevation and deck plans, the general exterior form of the boat is shown with the sheer of gunwale, length of keel, and rake of stem and stern-posts. The dotted lines of fig. 1 show the position and dimensions of the air-chambers within board, the relieving-tubes, and ballast. In fig. 2, A represents the deck, B the relieving-tubes (6 inches in diameter), C the side air-cases, D the end air-chambers, E ballast, F ventilators to admit of a free current of air under the water-tight deck, G ventilator to receive pump. In fig. 3, the exterior form of transverse sections, at different distances from stem to stern, is shown. Fig. 4 represents a midship transverse section, A being sections of the side air-cases; B the relieving-tubes, of the same depth as the space between the deck and the boat's floor; C, C, C, C, are spaces beneath the deck, 9 feet in length, placed longitudinally at the midship part of the boat, with solid chocks of light wood, or cases packed with cork, forming a portion of the ballast; *d* is a ventilator, having a pump fixed in it, by which any leakage can be pumped out by one of the crew whilst afloat. The festooned lines in fig. 1 represent exterior life-lines attached round the entire length of the boat, to which persons in the water may cling till they can be got into the boat; the two central lines are festooned lower than the others, to be used as stirrups, so that a person in the water, by stepping on them, may climb into the boat.

This life-boat possesses in the highest degree all the qualities which it is desirable that a life-boat should possess:—

1. Great lateral stability.
2. Speed against a heavy sea.
3. Facility for launching and for taking the shore.
4. Immediate self-discharge of any water breaking into her.
5. The important advantage of self-righting if upset.
6. Strength.
7. Stowage-room for a number of passengers.

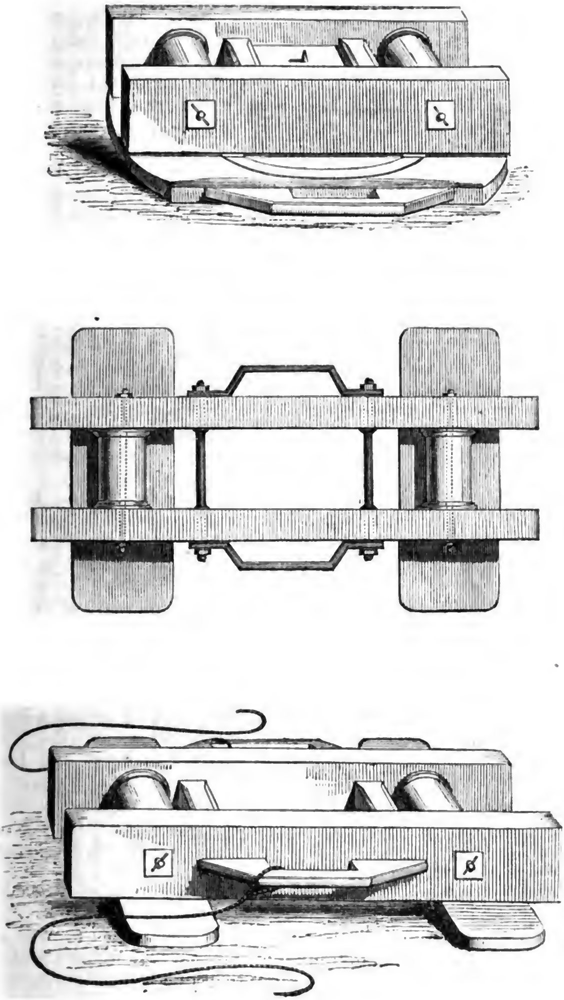
PLATE IV.

LIFE-BOAT TRANSPORTING CARRIAGE.



The carriage consists of a fore and main body. The latter is formed of a keelway A, A, and of side or bilgeways B, B, in rear of the main axle, the boat's weight being entirely on the rollers of the keelway. Its leading characteristic is, that, on the withdrawal of the long fore-lock pin *c*, the fore and main bodies can be detached from each other. The advantages of this arrangement are that the weight of the boat when she is launched from the rear end forms an inclined plane by elevating the keelway, yet without lifting the fore body off the ground, whilst to replace her on the carriage she can be hauled bow foremost up the fore end or longer incline. The bilgeways B, B, are needed at the rear end, that the boat may be launched in an upright position with her crew on board; but they are not required at the fore end of the carriage. The boat is hauled off the carriage and launched into the sea by a rope at each end of the boat rove through the sheeve *d*, having one end hooked to a self-detaching hook at the boat's stern, and the other manned by a few persons on the shore, who thus haul the boat and her crew off the carriage and launch them afloat at once with their oars in their hands, by which means head-way may be obtained before the breakers have time to beat the boat broadside on to the beach.

PLATE V.



The first lifeboat was that built in the year 1789 by Mr. Greathead at Shields. The utility of this boat being proved, she was soon followed by others, the second one being built in the following year, at the same port, at the expense of the then Duke of Northumberland. All the ports on the north-east coast, and on the east coast of Scotland, soon had their lifeboats, which were mostly provided and maintained by funds collected in the shape of a small voluntary tax on shipping entering the several ports. In Lincolnshire, Norfolk, and Suffolk, associations were formed which provided the coasts of these counties with lifeboats from funds raised by voluntary contributions.

In 1824 the National Institution for the Preservation of Lives from Shipwreck, now the Royal National Lifeboat Institution, was established in London by influential City merchants and other gentlemen, the late Thomas Wilson, Esq., then M.P. for the City of London, and the late Sir William Hillary, Bart., of the Isle of Man, taking a leading part in it; and His Majesty George the Fourth becoming its patron. That institution granted honorary and pecuniary rewards for services in saving lives from shipwrecks, and assisted local bodies in placing lifeboats on the coasts. Some of those boats remained nominally in connection with it, but the institution undertook no superintendence or control of them on the coast. The boats mostly built under its direction were small single-banked boats rowing six oars, similar in principle to the Norfolk and Suffolk sailing lifeboats; but having more water-space within them, and insufficient means of relieving themselves of water. They were designed by the late George Palmer, Esq., of Nazing Park, for many years an active and zealous member of the committee of the institution. Some of them, stationed chiefly on the Island of Anglesea, rendered good service.

As time went on, however, the general interest in the lifeboat service seems to have waned. Some of the local associations died a natural death. For want of proper superintendence the lifeboats in too many instances were suffered to go to decay. At places where wrecks were not very frequent the boats remained for many months without being put into the water, and in consequence, when wrecks did happen, the local boatmen felt no confidence in them, and would in preference go off to wrecks in their own boats. There were often also no funds to pay them for their services. In fact the whole system, if that could be called a system which had no general organisation, had broken down, and there were, perhaps, not a dozen really efficient lifeboat stations in the United Kingdom. The National Institution was also becoming every year less known, and its resources annually diminishing. Meanwhile, the number of wrecks did not diminish, for the winter's storms raged as of yore, and the increase of trade almost necessarily brought with it an increased number of casualties amongst shipping.

Such was the state of things when in 1849 the fatal accident occurred to the Shields lifeboat, by which twenty brave men lost their lives.

But, as we often witness in this world, on a small scale as well as a great, it pleased God to bring good out of evil—and the widow's wail and the orphan's cry wrought that which, perhaps, no less affecting, no less heart-rending a stimulant would have sufficed to do. The immediate effect of that melancholy incident was the resuscitation of the society

already referred to, now to become the truly *national* institution which it is this day. I am not now about to relate, in detail, its history. It will suffice to say that in the year following that disaster it aroused itself from sleep; its managing committee was invigorated by new, and younger, and some professional blood. The Duke of Northumberland accepted the office of its president; Her Majesty the Queen being already its patron, and His Royal Highness the late lamented Prince Consort one of its vice-patrons. Its present zealous and able secretary, Mr. Lewis, was appointed. It commenced the building of that fleet of lifeboats which now encircles our shores, numbering no less than 121, more completely and efficiently equipped than ever were lifeboat establishments before; which have cost nearly 50,000*l.*, and have already saved nearly 1,000 lives. It undertook the immediate superintendence of that fleet through the instrumentality of an honorary local committee at every station, a periodical inspection by an officer of its own, with a system of quarterly and especial reports from its local committees to the central one in London. It established a fixed scale of salaries to the coxswains, and of payments to the crews of its lifeboats, both for services to wrecked persons, and for a quarterly exercise in its boats. Finally, by the tangible, visible effects of its exertions, it succeeded in enlisting that public sympathy and support which in this country is happily so open-handed when shewn to be really required, and which have made it, and now uphold it, as one of the most glorious institutions of our land.

As an officer of the institution, I am not in a position to name those of its committee of management who have especially devoted time and labour gratuitously to this great work. Some of them have gone to their reward; those who are still amongst us will feel their chief compensation to be in the approval of their own consciences, and at the prospect of the good in the performance of which it has been their privilege to take a part.

Despite, however, this fleet of 121 lifeboats, and of 48 others locally provided and supported; and despite the numerous rocket and mortar stations on our coasts; there remains the melancholy fact, that an average of 800 lives are lost annually on and around our own shores alone, proclaiming, solemnly though silently, that for humanity's sake, and for the national credit, no exertions should be spared in providing every possible means for the conveyance of succour to the shipwrecked, from the shore; and also proclaiming in still more eloquent if not indignant terms, that some attempt should be made towards providing for the greater safety of the seamen in our home and coasting trade, by the adoption of measures both precautionary and remedial on board our merchant vessels themselves.

Friday, January 24th, 1862.

Lieut.-General the Honourable Sir EDWARD CUST, K.C.H., in the Chair.

OUTPOST DUTIES.

By Colonel R. Wilbraham, C.B., Governor, General Hospital, Woolwich.

It is, I assure you, with unfeigned diffidence that I have undertaken the task of delivering a lecture here to-day on Outpost Duties.

In the flattering invitation which I received from your Council to lecture before this Institution, the choice of subject was not left to me, or I should scarcely have ventured to select one which is at once so important, and so difficult to treat, as that which has been entrusted to me.

The incalculable importance of the efficient performance of these duties is well summed up in a few words by Marshal Bugeaud. "A good system of outposts," he remarks, "should not only guarantee an army against surprise, but should give it the power of refusing an engagement by a timely retreat—in a word, of fighting only when and where it pleases."

With the exception of the scientific branches of military education, the most difficult attainment of a soldier is, without doubt, a thorough knowledge of the varied duties of light troops. If we look through the military annals of our own and other countries, we shall find how rare are the instances of officers who have thoroughly mastered this part of their professional training. In our own service, when we have named Sir John Moore—the creator, as he may be called, of our light infantry system—and a few of his aptest scholars—such men as Sir Sydney Beckwith and Lord Seaton—we have, perhaps, named all who have distinguished themselves above their companions in arms as light infantry officers.

Among the Germans there are several names which will readily occur to many of my hearers—such as those of Thielmann and Lutzow in the War of Liberation in 1813—though their exploits belong, perhaps, rather to the separate field of partizan warfare. I may, however, instance Marshal Blücher, whose indomitable energy and enterprise made him especially dreaded by the French outposts in the early campaigns of the Revolutionary War.

No amount of mere instruction will make a first-rate light infantry officer, unless it be combined with natural intelligence and a good eye for a country; but, at the same time, instruction, and, still more, the instruction of experience, will greatly improve every one, whether officer or

soldier. The result of the first may be seen in the immeasurable superiority of the light troops which had the benefit of Sir John Moore's training in the camp at Shorncliffe—regiments taken at hazard from the whole British army; that of the second, in the unrivalled excellence of the Light Division in the later campaigns of the Peninsular war.

It would be needless before an exclusively military audience to expose the fallacy, too prevalent among us of late, of supposing that a lesser amount of training will suffice to render soldiers fit to act as light infantry than would be required to enable them to take their place in the line. Those who hazard such an opinion are misled by the facility with which the parade movements of light infantry may be learnt by zealous and intelligent men. They forget, or rather they are not aware, how small a part these movements form of the education of light troops—how valueless they are unless grafted on the steadiest battalion drill. Confidence in themselves and in their comrades will alone enable them to skirmish with vigour; to keep up their fire with coolness as long as their post is tenable; to fall back without confusion when outnumbered; to oppose a solid wall to the most sudden attack of cavalry;—and this confidence is, as every soldier knows, the slow growth of discipline and drill.

Raw and inexperienced troops have won great battles—perhaps, in some cases, they may even do better than older soldiers, from not fully appreciating their danger; but writers on military science, of all nations, agree that, for the adequate performance of outpost duties, the most careful selection of troops is requisite. One of the highest authorities on these matters—the Prussian general, Decker, whose treatise on the secondary operations of war has become a text-book in all European armies—expresses himself in the following strong terms: "To make 'la petite guerre'" (it would not be easy to translate this phrase into English, but it conveys its own meaning), "to make 'la petite guerre' with newly-raised troops and uninstructed officers would be a most difficult undertaking, and one from which it would be hopeless to expect success."

It is, I trust, needless for me to say that I do not make these remarks in any degree in disparagement of our Volunteers, but merely to prove, what I have often told them to their face, that, in the event of their being called into the field against an invading army, composed, as that army would assuredly be, of the very choicest troops, their chief value will be found, not as light infantry for the difficult duty of outposts, but as troops of position in support of, or side by side with, troops of the line.

All that zeal, and intelligence, and pluck can do, I give them full credit for doing; but it would be virtually denying the necessity of the army as a profession if we were to admit that those who devote a few leisure hours to their military duties could perform the most difficult of those duties as well as those who make it the study of their lives, and, from what I know of the volunteers, I feel sure that they themselves would be the first to acknowledge the justice of Decker's remarks.

As I was given to understand that my audience would, in all probability, comprise but few young officers, I have not attempted to lay down any regular system of instruction for the performance of outpost duties. Even had it been otherwise, I should have preferred endeavouring to awaken in them an interest in the subject, which would lead them to study it for

themselves in those standard works which are now within every officer's reach. I have, therefore, thought it better to make such general observations on the province of light troops as suggested themselves to me, either from reading or from personal experience, illustrating them by examples drawn from military history. By this course, I hope, while conveying at least indirect instruction, to make my lecture not altogether without interest to a mixed audience.

Indeed, the definite rules for the guidance of officers on piquet may be reduced to very few. In our own Book of Field Exercise these rules are laid down very clearly and concisely, and, if carefully read, would give a young officer a very fair insight into the theory of outpost duty. But this is a branch of a soldier's education which, more than any other, needs to be learnt, not by theory only, but by practice.

Did one not know by experience how often the most self-evident axioms of war are neglected or contravened even by those who ought to know better, one would be tempted to smile at the simplicity of some of the rules laid down, and even strongly and repeatedly enforced, in the elementary works of all nations, such, for instance, as exhortations to vigilance, which, one would think, ought to be unneeded in presence of an enemy, or the recommendation of precautions such as one would suppose must occur to the mind of even the most inexperienced. But when we see that master-minds like Frederick the Great, in their instructions to the officers under their command, consider no detail too trivial to dwell upon, we cannot but recognise the wisdom of endeavouring to supply by rules the want of that foresight and presence of mind which are so needful in service of this nature, but the possession of which is so rare a gift.

The systems of different services are becoming gradually more and more assimilated, as might naturally be expected from the experience of their comparative excellence during the long wars of the Empire. Whatever is faulty or defective in the system of any army is soon detected, to its cost, when brought into collision with a better system. Still the national characteristics will be more or less preserved. Our neighbours the French, for instance, who like to reduce everything to system, enter into minutiæ which we should never think of. In a recent work of much merit by the Professor of Military Art at the Imperial Academy of St. Cyr, there are diagrams showing the several geometrical figures which a corporal's patrol should form, according as it is composed of from three to eight men.

But, though the first principles of outpost duty are universal, and can rarely be departed from with impunity, their application may be infinitely varied according to the nature of the country, the character of the enemy to whom you are opposed, and the constitution of your own force. Indeed I may say that they must be greatly modified by these considerations. This would be more especially the case when European troops find themselves engaged in warfare with half-savage nations; as, for instance, the French in Algeria, or we ourselves in New Zealand and Kaffraria. When opposed to disciplined armies of whatever nation, the safest rule is to treat your enemy, however unenterprising he may have hitherto shown himself, with due respect; for, as Marshal Bugeaud remarks, "one intelligent and energetic man may change the habits of an army." "An army counting

on the mistakes of the enemy," says Decker, "would itself commit the most fatal of mistakes."

A high authority on all matters connected with light infantry, the late Sir Harry Smith, related to me an instance of the heavy penalty incurred by a French division in the Peninsula through neglect of this rule. It had been for some time in face of a Spanish force, and had doubtless been in the habit of driving in their piquets with ease whenever it thought fit. At daybreak one morning on came the French, with their usual impetuosity; and, presuming on their former success, left their supports too far behind. But, unfortunately for them, the Spaniards had been relieved during the night by a British division, and the outposts had been taken up by the Rifle Brigade. The consequence was that they met with a very different reception, and were driven back with heavy loss.

Decker, in the work to which I have already alluded, attempts to classify the different nations of Europe in respect to their qualities as light troops. To the Germans he, as a Prussian, of course awards the palm. Indeed, in another part of his book, he goes so far as to assert that in Spain the Duke made use of his German troops only for outpost duty! The French he calls "confident," meaning of course over-confident; the Russians "dangerous," on account of their swarms of Cossacks; the Spaniards "lazy;" and, what concerns us most nearly, he calls the English "heavy," —*pesants*.

Now if we try, as far as possible, to divest ourselves of national prejudice, what will be our estimate of British soldiers as light troops? That they are less intelligent than French soldiers we must, I think, allow. The fact of the conscription embracing all ranks will go far to account for this; in proof of which we need only look to the superior aptitude of our Volunteers for learning their drill. I am speaking at this moment solely of intelligence.

Napier, in his History of the Peninsular War, asserts that the army lay down to rest with a feeling of greater security when the cavalry of the German Legion held the outposts, than when they were taken by our own light dragoons; and I suppose that there must have been some ground for this assertion. It should, however, be borne in mind that the Germans were old campaigners when they joined the British army in the Peninsula, whereas our own cavalry had never taken the field before. I may here remark that the care and the detail with which the duties of outposts are laid down in German military works seem to show not only the attention paid by them to this subject, but their national aptitude for warfare of this nature.

My own experience would lead me to think that the British soldier is not so watchful as the foreigner. I have not forgotten that during the first winter on the heights of Inkerman, when our outpost duty was the most harassing and the most critical, our poor fellows were sadly overworked and underfed, and that under such depressing influences watchfulness was doubly hard; yet even under more favourable circumstances there certainly was a want of vigilance which it required all the exertions of their officers to guard against. And this, I think, may in some measure be attributed to a constitutional indifference to danger. Certainly it is better than the opposite extreme of over-sensitiveness to danger, which

leads to so many false alarms, even if it does not entail more serious consequences.

Considering the indiscriminate nature of our recruiting, which brings into our ranks many men physically and morally unfit for the duties of light infantry, there is much to be said in favour of our former system of flank companies; but doubtless the disadvantages more than outweighed the advantages of this selection. All distinctions between regiments as well as between companies is also virtually done away with; for, though some few are still called light infantry, yet, armed and trained as they all are alike, there is no real difference, except that a long-established good system of training, and the prestige that attaches to the old Light Division, makes such regiments as the 43rd, 52nd, and Rifle Brigade hard to equal.

But, whatever drawbacks there may be to the present system, the numerical weakness of our army compared with those of other powers, and the consequent necessity of every part of it being prepared to act in any capacity, have left us no option, and we must make the best of the materials we have.

I may remark here, that in the French Army the distinction between heavy and light regiments of the line has been abolished within the last ten years; but, on the other hand, the number of the battalions of chasseurs has been augmented, and greater care than ever has been bestowed upon their composition, and upon their training, which, as all my military hearers are aware, is special, and calculated to develop to the utmost all those physical and mental qualities required for the efficient performance of the duties of light troops. The chasseurs are recruited in particular departments of France, especially, if I am not mistaken, in the mountainous district of Auvergne.

But, to return to our own service, there is a coolness in danger, for which the British soldier has been always conspicuous, which should go far to make him superior to all others for outpost duty; for it is when acting individually, or in small parties, that the qualities of self-possession and self-reliance become of highest value; and the more so when combined, as is the case with our soldiers, with physical superiority. It is only necessary to read the secret instructions of the Great Frederick, and some of Napoleon's letters to his brother Joseph, written just after the battle of Maida, to see that it is not in every army that coolness under fire can be reckoned upon, as, happily, it may be with us.

Those who have served with a French army in the field, must have perceived that they invariably attempt to make up for their inferiority in this respect by an increase of numbers. A detached post which we should hold with a subaltern's party, they would occupy with a whole company; and, in place of a chain of sentries along their front, they would sometimes, in exposed positions, plant a chain of small piquets.

Still, our neighbours, with their usual self-complacency, are perfectly satisfied of their vast superiority to us as light troops; in proof of which I need only adduce the following remark made by a French marshal to an English officer, since the Russian War: "Should it ever be my ill fortune," he said, "to be opposed to an English army, do not suppose that I should be so foolish as to attack them in their position; nor should I, perhaps,

await their attack in mine; but I would harass them out of their lives, and never allow them to close an eye."

On the principle of "fas est et ab hoste doceri," let us ask ourselves whether this be indeed our weak point, and, if it is, let us use every exertion to strengthen it.

Within the last few years, far more attention has been paid to this important subject than formerly; to which the introduction of the rifled musket has greatly contributed. It was felt that it was too costly and too perfect a weapon to be placed in unskilled hands, and that, if it was valuable when used by troops of position, it might be made tenfold more so when used by light troops thoroughly instructed in its use.

It is, I think, impossible to overrate the benefits that the army has derived from the establishment of the School of Musketry, not merely from the improvement in our rifle practice, important as that is; but from the increased zeal and intelligence of all, whether officers or men, who have passed through a course of training at Hythe—qualities which they, in their turn, impart to those who pass under their instruction. The faculty of judging distances correctly is, in itself, no slight advantage in light infantry movements, independent of the mere aim; and the increased confidence of the soldier in his weapon, resulting from his better acquaintance with its powers, must necessarily increase his confidence in his own means of resistance against any enemy to whom he may find himself opposed.

It is a question of the deepest interest, and one which at the present moment is occupying the thoughts of our most scientific officers—naval as well as military—how far the introduction of what the French call "armes de précision," will affect all operations of war; and, with your permission, I will offer a few remarks upon its bearing on that particular branch of which we are treating.

I have had the advantage of discussing this subject with General Hay and Colonel Wilford—two very high authorities—and it is the decided opinion of both, that the Enfield rifle is essentially a defensive weapon. A very cursory examination of the grounds on which this opinion has been formed will convince every one of its validity. It is obvious that the Enfield rifle is used with far greater effect by stationary troops than by troops in motion. It is in the hurry and excitement of a rapid advance—and in attacks upon outposts advances, to be successful, must be rapid—that rifled muskets are of least value. With a constantly and rapidly decreasing range, the sights are no longer of use, even were the men disposed to use them; whereas the piquet, which in most cases must have had time to ascertain, if not by actual measurement, at least by leisurely survey, the distance of every point at which an enemy can show himself, is prepared to welcome him with a concentrated fire.

Think how this advantage may be increased by an abattis, or any other obstacle, natural or artificial, which may have the effect of impeding, even for a few moments, the advance of the attacking force. Think too of the distance at which, in a moderately open country, the assailants must come under fire, and it will be evident how greatly the increased range will be in favour of the defending party.

On the other hand, it cannot be denied that henceforth it will be neces-

sary for outposts to take up more distant, and consequently more exposed, positions than has hitherto been usual, in order to prevent the camp or bivouac from being annoyed by the enemy's artillery—I may even add, by their riflemen. This will, as a necessary consequence, lead to an increase in the number of supports requisite to insure the safety of the advanced posts, in the event of their having to fall back upon the main body.

We may see from these considerations how expedient it is that all troops should be thoroughly trained to act as light infantry. With the formidable weapons now in use,—and who can say that they have yet reached their limit?—not only will more numerous outposts be needed, but increased rapidity of movement generally, and the power of advancing or retiring without disorder under fire in looser formation than the column or even than the line.

One certain effect of the long range will be that in future piquets will feel the necessity of protecting themselves by field works of one kind or another, whenever the nature of the ground affords them no cover. I should mention, however, that the French are of opinion that the habit of entrenching themselves makes the outposts timid, and therefore do not permit it except under special circumstances. Our own experience in the trenches goes far to confirm this opinion.

I must premise that the observations I am about to make on outpost duties apply solely to the employment of infantry. Having received my military education in the Rifle Brigade, that branch of the service has been of course my special study; and in the field I have had no experience of the employment of cavalry and artillery in those duties. Such an extension of my subject, did I even feel myself competent to it, would also make it difficult to compress it within the limits of a lecture.

In a level and more or less open country cavalry would evidently have decided advantages over infantry in the celerity of their movements, and in being able to observe the enemy at a greater distance, and would therefore be largely employed. But, beyond giving to the infantry outposts—for these would of course not be superseded by the cavalry piquets—some increase of security, it would not, I conceive, materially affect the dispositions that an officer in charge of outposts would make, inasmuch as, from the wide arc described by a chain of cavalry piquets, it would be impossible at all times to prevent even large bodies of troops from passing unperceived through their intervals. For instance, in the operations on the Coa in 1810, one regiment of German hussars covered a front of twenty-five miles, and was several miles in advance of the most advanced infantry outposts.

As regards the employment of cavalry, I will only add that, in all countries except such as are absolutely impracticable for cavalry—and our Chairman can tell us from personal experience, that even the most rugged parts of the Pyrenees were not impracticable—small bodies of horse, whenever available, are invariably attached to the infantry outposts for the purposes of communicating more rapidly with the main body, of furnishing patrols, and of occupying with vedettes points which are too distant to be prudently held with infantry. The manner in which they should

perform these most important duties will, I hope, form the subject of a future lecture in this place.

The employment of artillery presupposes operations on a larger scale than comes within the scope of this lecture, which will treat only of the handling of individual piquets; nor has it any direct bearing upon the subject, its value consisting in the support that guns afford to the piquets whether acting on the defensive or the offensive.

In its main features the system of outposts adopted in the English, French, and German armies is one and the same. In all there is, as a general rule, a triple cordon to protect the main body; first, the chain of sentries, which with us are always double (with the French and Austrians they are only doubled on posts which require more than ordinary vigilance); next, the line of piquets, properly so called, from which the sentries are furnished; and lastly, the supports. Where the outposts are covering a large body, and consequently are thrown far in advance, there would be besides these, a reserve, which would be furnished from the main body, and would occupy some strong position covering the camp. The supports will be posted at central points. Where several roads converge towards the camp the point of junction must be strongly held, in order that support may be sent in whatever direction it may be needed, and that the advanced posts may have a rallying point on which to fall back.

The nature of the ground may further require the detaching of small piquets of support to strengthen weak points of the line, or to keep up a communication between the piquets and their advanced sentries where the latter are concealed from view by inequalities of the ground. Of course service of this nature cannot be fettered by specific rules.

The comparative strength of the component parts of the outposts is determined by the necessity of having a sufficient number of reliefs to divide the duties, which become the more severe the nearer to the enemy. Thus the piquets must be of at least three times the number of the sentries they are called upon to furnish. The supports are only required to be of equal strength with the piquets, as under ordinary circumstances piquets are seldom relieved during their tour of duty, but, as the supports are required to send out frequent patrols, it is desirable that they should be of sufficient strength to enable them to perform this duty without weakening themselves too much.

Whenever possible the outposts should all belong to the same corps or brigade. It ensures greater unity of action; and the confidence that the men naturally feel in their comrades, and in their officers, is a source of strength.

I have already observed that, in the application of the rules laid down for outpost duties, an officer must be guided by the nature of the ground he is ordered to occupy. It is obvious that in an unenclosed and unwooded country a comparatively small number of piquets will suffice to cover all the approaches effectually; while in a country dotted with patches of wood, or otherwise intersected, it is almost impossible with any number to guard against a surprise. In such a case the only remedy is to send out frequent patrols.

In the combat of Maya the value of patrols under such circumstances

was strongly exemplified. A round hill in front of the British position masked the movements of the enemy in one direction. It was too distant to be occupied by night. In the morning a staff officer having patrolled round it, discovered enough to make him order up the light companies in support of the nearest piquet, which was in a very exposed position. They had only just time to form on a neck of land, a short distance in rear, when a French division appeared on the summit of the hill, followed by a second. The piquet was forced back with great loss upon the light companies, who with difficulty sustained the shock until reinforced. Upon this Napier makes the following observations: "The Portuguese cavalry patrols, if any went out, which is uncertain, might have neglected their duty, and doubtless the front should have been scoured in a more military manner; but the infantry piquets and the light companies so happily ordered up were ready, and no man wondered to see the French columns crown the great hill in front of the pass."

Perhaps one of the surest tests of a good light infantry officer is to be able to cover his front thoroughly with as small a number of men as possible. A good disposition of your outposts will more than compensate for a deficiency of numbers. The first impulse of an inexperienced officer is to occupy every commanding position, which is quite unnecessary even had you the men to spare. Even an experienced officer will generally find on revisiting his advanced posts that he can make a more judicious and a more economical distribution of his force.

One of the best proofs that the distribution is really judicious will be the fact of his own posts being hidden from the view of the enemy, while themselves overlooking the whole country round. Yet, desirable as this concealment is, he must not sacrifice to it the advantage of gaining an extended look-out.

In many, I might perhaps say in most, cases the features of the country will mark out the natural cordon of the outposts. There will be either the course of a stream or a line of road, or a ridge of heights to determine this point for you. But in a country abounding in small hills it is difficult to know where to stop with your piquets and sentries. There will always be some eminence just beyond your actual position which it would be desirable to occupy. Here great judgment is required, for the advantage to be gained may be more than balanced by the disadvantage of a too great extension and consequent weakening of your line. Yet this latter alternative must sometimes be preferred, for it is better to risk the loss of a post than to compromise the safety of the army. An instance in point may be found in the battle of Albuera, where Napier attributes the imminent danger of the Allies to the neglect to occupy with a piquet a hill, behind which the French were in consequence enabled to make their disposition for the attack unperceived.

This is a question which, like many others in this most responsible service, must be left to the judgment of the officer in command. It may, however, be laid down as a fundamental rule that wherever possible the outposts must feel those of the enemy. To ascertain his exact position is one of the chief objects for which they are posted. The increased rapidity of the movements of troops in modern warfare renders this task at once the more necessary and the more difficult of execution. Under

any circumstances the outposts must be sufficiently distant to give the main body ample time to get under arms.

A happy mixture of caution and boldness will in most cases be successful, it will inspire your men with greater confidence than more timid measures. Danton's celebrated saying, "De l'audace ! de l'audace ! et toujours de l'audace !" may in some cases be well applied to the conduct of outposts, provided of course that daring does not become foolhardiness. If the line of retreat of an advanced piquet has been carefully studied, it will generally be able to fall back with safety in the daytime even before a greatly superior force. At night there is probably less risk of its being cut off, for it has the advantage of a better acquaintance with the ground, and in a night attack the movements of the assailing force are rendered hesitating by the fear of falling into some unseen danger. If in immediate contact with an active enemy, the security of a piquet at night may be greatly increased by changing its position from time to time, even if it be only by moving it a few yards to the right or left. It is almost unnecessary to say that, under such circumstances, the night post of a piquet must always be taken up after dark, and that the ordinary precautions of preserving silence and having no fires must be strictly observed. The sentries will, as a matter of course, be withdrawn from the heights into lower ground, in order that they may better discern the outline of an advancing body against the sky.

In most works on outpost duty it is laid down as a rule that the chain of piquets should be drawn closer by night. Marshal Bugeaud, on the contrary, insists, and with some show of reason, that it should be extended. "In the daytime," he says, "it is the eye that guards," whereas at night the enemy's approach can only be known by actual contact, and therefore he must be felt for at a greater distance in order to guard against surprise.

Still it would hardly be advisable to extend your chain of outposts by night, or even to occupy as much ground as by day, for the necessity of planting your sentries closer to each other would entail a considerable reinforcement of the piquets. As, however, in a night attack the enemy would scarcely venture to quit the roads for fear of missing his way, it might be expedient to station advanced piquets on the principal approaches, not posting them across the road, but on either side. In a work on outposts, published a few years since in Austria, it is suggested that on a dark night withered branches should be thrown upon the road some forty or fifty paces in front of the post, that the approach of any party might be betrayed by the rustling of the leaves. In the same book mention is made of small posts called *schnarr-posten*, which I never heard of before. The literal translation is rattle-posts, and their duty is simply that of watchmen. They are thrown out on dark nights in front of all piquets, whether infantry or cavalry, to listen for the approach of an enemy. In the latter case they are dismounted and stationed at some distance from the piquet, that the noise of the horses may not interfere with their hearing. But, after all, the security of a position will be equally attained, and with less risk, by sending out frequent patrols, especially towards break of day.

Night attacks are seldom resorted to in these days. Even when the

preconcerted instructions have been fully carried out, which rarely happens, the confusion and uncertainty inseparable from such attacks seldom allow of any decided advantage being gained. Our own experience in the Crimea shows how easy it is to miss your way at night even on ground with which you are thoroughly acquainted.

In a little work of Marshal Bugeaud, an anecdote is related which bears upon this point: An officer received orders one evening to occupy a certain position—a somewhat exposed one, no doubt; he ventured to remonstrate, saying that his piquet would certainly be cut off before morning. The general then ordered him to take a party after dark and carry off an advanced post of the enemy, the position of which he pretty well knew. He now began to speak of the difficulty of finding by night exactly where the post lay; upon which the general remarked that probably the enemy would experience the same difficulty in finding his post, and directed him to obey his first order. The Marshal then adds, as the result of a long experience, that if these duties are performed with common intelligence the piquets will run no risk, and the army will camp in security. An officer in command of a reserve, or of a support, having several piquets in advance of it, may find it useful to adopt a plan which we tried in the Crimea. At night he will sometimes find it difficult to know from which of the piquets a shot is fired, especially if he is not familiar with the ground. But by placing sticks or heaps of stones in front of his support, pointing in the direction of each of the several advanced posts, he will find them of great assistance in determining from what point the firing proceeds.

Attacks are usually made at daybreak, all the preliminary dispositions having been made under cover of night. For this reason troops, when near the enemy, are always under arms an hour before dawn, and remain so until intelligence is received from the front that all is quiet; for the same reason the relief of the outposts usually takes place at this hour, in order that they may be in double strength to repel any sudden attack. The old piquets are not withdrawn until there is sufficient light to discern objects at a considerable distance. The soldier's well-known criterion of daylight is when you can see a white horse a mile off!

It was a frequent practice with Napoleon to make a threatening movement with his outposts at dusk, in order to throw the enemy on the defensive, and disconcert any offensive movement that he might have been planning.

If a piquet, in retiring before a superior force, finds itself hard pressed, it is sometimes advisable to diverge a little from the direct line of retreat, especially if by so doing you can draw the enemy into more broken ground. In both the French and Prussian services this diagonal line of retreat is enjoined as the rule. By so doing you also leave the front of your support clear, and expose the enemy to a flank fire. Care must, however, be taken not to lose sight of the advancing force, as this might compromise the safety of your support. It may also be advantageous to retire in two divisions, which can afford each other a mutual support.

It will depend upon circumstances whether, in the event of the piquets being attacked, they should fall back upon the supports, or the supports advance to their assistance. The latter is somewhat dangerous, unless a

corresponding advance be made by the reserve, if there be one, or reinforcements be at once sent forward from the main body to take their place. If, however, the piquets be hard pressed, and it be important to maintain the position, the supports must advance without hesitation, sending immediate notice to the rear. Under no circumstances must the supports fall back until they have rallied to them all the advanced piquets. Outposts, even when seriously threatened, must not lightly relinquish their ground; by showing a bold front they may often force the enemy to discover his force and even to develop his intentions. All waste of ammunition by unnecessary or too rapid firing must be carefully checked. The temptation to the latter fault will be greatly increased if ever it should be decided to arm our infantry with breech-loaders. The former is still more objectionable, for, besides throwing away ammunition, which it is always difficult, and sometimes impossible, to replace, it has the effect of needlessly alarming and harassing the troops, to whom when on active service every hour of repose is of incalculable value. It is only in actual self-defence, or when the intended advance of the enemy is beyond a doubt, that the sentries should ever fire. If they have only reason to suspect that an attack is meditated, it is better to send a man to the rear to warn the supports, without obliging the main body to stand to their arms.

There is, perhaps, no campaign on record of equal duration, and on so large a scale, which was so uninstructive in all that relates to outpost duties as the late war with Russia. Lallemand in his excellent treatise on the minor operations of war, defines the object of outposts as twofold: "The safety of the corps that establishes them, and the observation of the enemy's troops." Now in the Crimea the nature of the ground, and other causes, restricted us entirely to the former of these duties. In the Second Division we had, during the first few months of the siege, heavy and harassing piquet duties, but their sole object was to guard our own position, as far as possible, against a surprise; and night after night the same posts were necessarily occupied to cover the approaches to our camp. The bulk of the Russian army lay on the heights beyond the Tchernaya, at a distance of more than two miles, and in a position so unassailable that they needed no outposts and probably had none.

Nor has the most recent European war been more instructive in this respect, though from the introduction of improved firearms we might have expected some valuable experience. In the first place, the rich plains of Lombardy are so highly cultivated, and covered with such luxuriant vegetation, that military operations were almost confined to the high roads, at least during the earlier part of the campaign. And in the second place, if I may presume to say so, the outpost duty of both armies appears to have been conducted with so much carelessness that we have nothing to learn from it. It is, I believe, an undoubted fact that on the eve of the battle of Solferino, the two armies were, at some points at least, not more than five miles apart, and yet remained in utter ignorance of each other's approach until they came into actual collision.

In studying, therefore, the second and most interesting portion of the duties of outposts, or rather the combination of the two, we must look to the annals of former campaigns for our instruction, and nowhere can we

find it more readily or more fully than in the history of the Peninsular War—a war carried on between two of the best trained armies of Europe, and on a scale which enables us to follow and criticise the movements, not merely of large bodies of troops, but of brigades, single regiments, and even detached companies, thus affording practical instruction to officers of every rank. That war possesses, moreover, this additional advantage, that the one side consisted of troops of our own nation, which will make it a surer guide for any future operations in which we ourselves may be called upon to take part.

Perhaps the best study for light infantry movements in the field will be found in General Craufurd's celebrated operations on the Coa in 1810, and in the campaigns of 1812–13 in the Pyrenees. The first of these will teach us how these movements should be conducted in a comparatively level and open country; the second will give us valuable lessons in mountain warfare, and in the guard of passes and defiles.

It is laid down by all military writers, as the leading principle of outpost duties, that all engagements with the enemy must be avoided whenever possible, unless, indeed, the safety of the main body should imperatively demand the maintenance of a post at all hazards. This is implied in the name of secondary operations of war applied to these duties. Numerous instances are recorded of partial and even general actions having been brought on, and the best laid plans of the general defeated, by unnecessary and ill-judged engagements between the outposts. It seldom happens, or rather it should seldom happen, that outposts are forced into an engagement. It usually implies a want of vigilance or of prudence.

Now Craufurd, though a great soldier—and the value, even at the present day, of his standing orders for the Light Division proves that he was a great soldier—was in the constant habit of contravening this principle. He seemed to delight in provoking an attack, from the consequences of which he was on more than one occasion saved only by the excellence and gallantry of his troops. The force under his command was indeed composed of the finest materials. It consisted of Sir Hew Ross's troop of horse artillery, the well-known chestnut troop, the finest probably in the world; a regiment of hussars of the German Legion, excellent light cavalry; the 43rd, 52nd, and 95th, long and carefully disciplined by Sir John Moore; and two battalions of Portuguese caçadores, officered by Englishmen, and under such guidance admirably adapted to a service of this nature.

Such was their training, that, in the words of Napier, "seven minutes sufficed to get under arms in the night; a quarter of an hour, night or day, to gather them in order of battle at the alarm posts, with baggage loaded and assembled at a convenient distance in the rear; and this not upon a concerted signal, and as a trial, but all times certain, and for many months consecutively."

"Strong advanced guards," says Decker, "are exposed to the temptation of engaging the enemy unnecessarily." What wonder, then, that with such a force under his command—a little army in itself—this temptation should have been too strong for a man of Craufurd's fiery temperament, and that in his thirst for distinction he should at times have forgotten that the safety of the army was confided to his keeping!

In the Historical Record of the 52nd, recently published, the following characteristic conversation between the Duke and Craufurd is recorded. On the latter rejoining the army after one of these hairbreadth escapes, Lord Wellington asked him, "Why, Craufurd! where have you been? I thought you were lost." "No, my lord," said Craufurd, "I was quite safe." "Ah!" replied the chief, "that was all very well for you, but, by Jove! I was not."

Decker well remarks on this subject, that "the fact of an enemy not venturing to attack the outposts ought to be a sufficient reward for all the fatigues incurred in this harassing duty."

If I had allowed myself to make extracts from the many works that have been written on these operations by officers who bore a part in them,—such men, for instance, as our present Chaplain General, or my first captain, so well known as "Johnny Kincaid, of the Rifle Brigade,"—I might have made my lecture far more interesting to a mixed audience, or indeed to any audience; but I did not feel myself justified in doing so, unless the incidents recorded bore upon some principle of outpost duty. There is, however, scarcely a page that does not convey some useful hint, either as to what should be done, or what should be avoided; for even with such troops as the Light Division mistakes are at times inevitable.

At the combat of the Coa, for instance, where the division was hard pressed by an overwhelming force, which threatened to intercept its only line of retreat, the 43rd were incautiously thrown into an enclosure of masonry ten feet high, and having but one narrow outlet. Fortunately the masonry was not very solid, and by an united effort of the whole regiment a part of the wall was thrown down, just in time to save them from being cut off.

Now there is, perhaps, not much fear of an officer of ordinary intelligence compromising his detachment to such an extent as this, it being one of the first rules laid down in the Book of Field Exercise that a piquet must not shut itself up without orders; yet sometimes he might be tempted, by the apparent strength of a position, to occupy it, without sufficiently considering whether his line of retreat might not be endangered by obstacles of one kind or another immediately in his rear,—a long high wall, for instance, or even a hedge. I need scarcely remark that broken ground may sometimes be more favourable to the attacking than to the defending force, especially if it extends along a portion only of the front, and thereby renders that portion liable, by the delay it occasions, to have its flank turned. Perhaps some of my hearers may remember that at the battle of Nivelle the French lost several hundred men by throwing them into one of the fieldworks by which they had thought to strengthen their position. The Light Division drove back the troops on either side, and the detachment, completely cut off, surrendered to the 52nd Regiment. There is therefore no rule more necessary to be borne in mind than that of always keeping your line of retreat open; and, with this view, every officer in command of a piquet should carefully study the ground between him and his supports, settling beforehand in his own mind the spots on which a stand could be made, in the event of his being forced to fall back. This, as our drill-book points out, should be done during the march of the piquet to take up its position; for, if in close contact with the enemy, it

would of course be impossible for him afterwards to quit his post for this purpose. To seize at a rapid glance the leading features of a position requires experience, and young officers will find it a useful practice in their rides or walks through a new country to look upon every accident of ground with a soldier's eye.

But it is not solely with a view to ensuring the safe retreat of his own piquet that an officer should study the country around his post. Such knowledge may prove of the greatest use in determining the movements of the army whose advanced guard he may at any moment become. For this reason he should endeavour, by every means in his power—by personal examination, where possible, or by the report of his patrols, or by information gained from the inhabitants—to ascertain such matters as are most essential in a military point of view, such as the direction and state of the roads, the course and depth and bottom of any rivers or streams, the proximity of any defile or swamp, or other natural obstacle. In a word, the outposts should be the eyes of the army.

The officer who has the general superintendence of the piquets will, of course, give such instructions to each officer as he may think needful; and will acquaint him with any special object for his having been posted at that particular spot; but, under all circumstances, much must be left to his own zeal and judgment—still more to his sleepless and untiring vigilance. He must ever bear in mind, that one hour's remissness may render useless weeks of anxious watching, and, which is infinitely worse, may compromise the safety of the army, and defeat the most skilful combinations of the general.

It stands to reason that a piquet is at all times liable to be attacked by a greatly superior force; and this liability can only be met by an unremitting watchfulness. On this point the Great Frederick gives a piece of advice which will be valuable to all officers in command of outposts. He recommends, that they should take pains to convince their men of the necessity of that vigilance which they enforce; and he adds, as the result of a long experience in the field, that "the sleepers and the negligent are beaten by the wakeful and prudent."

For a piquet to be surprised is, of course, a disgrace to its officers.

If very near an enemy, the chain of sentries must be posted nearer to each other, especially by night, and one man of each file must patrol without intermission up to the adjoining post, while the other stands to his front, and keeps a sharp look-out. Under such circumstances the officer must be all eyes and ears, both for the security of his own piquet and for the general good. He will watch with suspicion the slightest symptoms of a movement within the enemy's lines, such as a cloud of dust in the daytime, a brighter or fainter blaze of the watch-fires by night, or the rumbling sound of guns in motion, or the neighing of horses. Signs trifling in themselves may serve to confirm or refute the reports of scouts and deserters, and therefore they should at once be transmitted to the rear, and, where possible, in writing, for fear of mistakes. Notice must also be sent to the adjoining piquets of any anticipated movement on the part of the enemy.

A laughable instance of over-suspicion occurred in the Second Division on the heights of Inkerman, during the winter of 1854–55. After dark

word was sent up from one of the advanced posts, that suspicious sounds were heard rising from the valley below, like the rumbling of wheels. An officer was sent forward to reconnoitre, and on reaching the edge of the valley he found, to his amusement, that they proceeded from myriads of frogs on the marshy banks of the Tchernaya.

However well the front may be covered by sentries, the piquets must still watch. A portion, smaller by day and larger by night, must always be ready. When a fire is permitted, one half only of the piquet should be allowed to sit round it at one time, while the other half keeps itself a short distance apart, and on one side, so as to take in flank any party that may suddenly fall upon them. The alarm-post must be fixed in rear of the fire, so as to give the piquet the double advantage of being itself in the dark and forcing the enemy to expose himself to the light. Piquet fires should be made, where practicable, in hollows, so as to be as much as possible hidden from the enemy. Sods or damp earth should be kept close at hand to extinguish them in a moment. It may sometimes tend to mislead the enemy as regards the site of the piquets, if fires are lighted at other points of the position.

One of the first duties of an officer on piquet is to place himself in communication with the piquets on his right and left, not merely with a view to forming a continuous chain and preventing bodies of the enemy from passing through, but also for the purpose of concerting a combined plan of operations in the event of having to retire. He should look upon his piquet as a link only of that chain—as it were a file in a line of skirmishers—and should conform his movements accordingly. However strong his own post may be, it is obvious that it is worse than useless to attempt to maintain it if the piquets on either side have been driven back and have left his flank exposed.

I may here remark that it is not usually by skirmishers that a position is carried. Columns of more or less depth, or single companies with closed files, break through the weakest points of the enemy's line, compromising the safety of the remainder, and forcing them to fall back in haste. This was pointed out very forcibly by Sir John Burgoyne in his remarks on the defence of the country against invasion, at a time when it was argued by writers in newspapers that skirmishers occupying our hedgerows could arrest the advance of an invading army. On the same principle the attack of a superior force will in most cases be more effectually checked by concentrating your piquet on the key of the position and receiving them with a close fire or with the bayonet. A striking instance of this occurred at the combat of Roncesvalles. It was of vital importance to secure the pass of Atalosti, but the French were nearer to the summit than the English. General Ross, however, who had preceded his brigade, had one company of the 20th Regiment in hand. Instead of attempting to check the advance of the French by the fire of skirmishers, he called upon them to charge the front of a French light infantry regiment which headed the column. They did so without hesitation, and, though eventually driven back by overwhelming numbers, the object was gained, Ross's Brigade reached the summit, and the pass was secured. An offensive movement may, with advanced posts as with armies, sometimes prove the best defensive.

When a piquet forms one extremity of the chain of outposts, the officer will, if possible, rest his outer flank on some strong point, taking care well to overlap the front of the main body. Should none offer, it will be advisable to refuse that flank, and further to detach a support towards it as a point of appui.

Every road which leads towards the camp must be carefully guarded. If there are more than can be occupied by the force at his disposal, the officer in command should close some of them by temporary obstructions. On no account, however, must he break up a road, without express permission, lest it should interfere with a meditated advance of the army. Still less must a bridge be destroyed without orders, though it may be rendered impassable for a time by the removal of a beam, or in some other way that admits of easy repair. With these exceptions it is not only allowable but incumbent upon an officer to strengthen his post by every means within his power—such as felling trees, constructing abattis, or throwing up rude entrenchments. With the improved musket these precautions, as I have already observed, become doubly needful. If the ground he occupies afford absolutely no shelter, it will be well to construct, for the sentries at least, the simplest form of rifle pit, such as were used by both sides before Sebastopol.

I need scarcely point out that in some cases it may be as necessary for the safety of a piquet to pull down walls and fill up ditches, as it is in others to build and to dig them.

The mode in which natural obstacles may best be turned to account and artificial ones created may be studied with advantage in Jebb's "Practical Treatise on Strengthening and Defending Outposts." I need only cite the defence of Hougomont as a proof of the readiness with which, by a few ingenious and at the same time simple expedients, a dwelling-house may be converted into an impregnable fortress.

Another important rule to be observed is that outposts and their supports should be placed on the same side of any difficult passage—such as a stream, a swamp, or a defile,—and, if possible, behind it. This rule cannot of course always be adhered to, for, at whatever risk, the movements of the enemy, or at least his actual position, must be discovered. For example: if you are covering the line of a river—I am here speaking of a small river which is either fordable or can quickly be bridged over—and the opposite bank is the higher, or of a nature to afford cover to troops, it will be necessary, whenever possible, to keep small posts beyond the river to prevent the enemy from assembling in force and falling upon you unawares. This course Craufurd pursued with success when covering the line of Azava, though at the imminent risk of having those posts cut off.

On the other hand, the neglect of this precaution led to the defeat of the French army near the Bidassoa, under the following circumstances: Its left flank rested upon that river, and when the piquets were posted the stream was found to be impassable; consequently it was deemed unnecessary to send even a patrol across to feel for the enemy. Now the opposite bank was covered with tall crops of maize, and the Allies took advantage of this to place a large force unperceived close by the water's edge. At low water—for the Bidassoa at that point is a tidal river—they suddenly

forded the stream, and falling unexpectedly upon the French, drove them back in confusion upon Urugna. Now had patrols been sent across the river as soon as the tide permitted, this defeat might have been prevented.

This example should teach us that no precaution can be neglected with impunity. A commander gifted with foresight will be prepared for any contingency however remote. To quote again from Marshal Bugeaud: "It is enough that an enterprise be possible, for a prudent soldier to take every measure to guard against it." Probably it did not occur to the French commander that the Bidassoa was affected by the tides; but rivers, whether tidal or not, require to be carefully watched, for in mountainous countries especially they are liable to sudden rises and falls, either of which may compromise the safety of an army. Napier mentions that the Agueda sometimes rose several feet during the night without any apparent cause.

And now let me give an example, drawn from our own records, of the advantage resulting from forethought in such matters. Shortly after the action at Sabugal one company of the 52nd and half a company of the 95th were posted on piquet at the bridge of Marialva on the Azava. A second company of the 52nd was stationed at a ford not far distant; the French in greatly superior force attacked the Marialva piquet and pressed it hard. Captain Dobbs, who commanded the other piquet, seeing that a good deal of rain had fallen during the past night, suspected that the ford which he had been set to watch was no longer fordable. Having ascertained this to be the case, he took upon himself to leave his post in charge of a corporal and file of men, and hastening with the rest of his company to the bridge, arrived just in time to save his comrades from being overpowered.

In warfare of this nature no advantage however trifling in appearance should be despised. Napier relates that at Barba del Puerco, on the Agueda, the French commander, wishing to drive in our piquets, collected his column after dark at the head of the bridge, and, waiting till the moon, rising behind him, cast long shadows from the overhanging rocks and deepened the darkness of the ravine, crossed at the double, bayoneted the sentries, and succeeded for a while in driving in our outposts.

Even artifices may sometimes be advantageously resorted to, to impose upon the enemy. Craufurd wishing to conceal the weakness of his numbers—he was keeping the field at that time with a weak division within two hours' march of 60,000 men!—disposed his troops in single ranks on the rising ground, while he used some horsemen to raise a cloud of dust in the rear as if reinforcements were ariving. In the same way it may be well in some cases to show your piquets and supports, though the general rule, as I have said, is to keep them out of sight. In making their retreat the French used sometimes to plant "dummies" round the abandoned watch-fires with shakos on their heads and poles placed besides them to pass for muskets.

In short, outpost duty presents a wide field for the exercise of those qualities most valuable in a soldier: forethought, presence of mind, and fertility of resources. Decker—I quote from the French translation, which has the advantage of the comments of a soldier of another nation—Decker says: "Enfin l'art de savoir se suffire à soi-même peut être regardé

comme l'âme de la petite guerre." Even in the most desperate cases it is wonderful what may be done by troops imbued with this spirit of self-reliance. In the action of the Coa a half-company of the 52nd found itself completely cut off by the rapid advance of the French. Nothing daunted, it lay concealed till nightfall, and threading its way under cover of the darkness through all the enemy's outposts, succeeded in rejoining its corps on the following day without the loss of a man.

Another invariable rule in outpost duty is to avoid as far as possible placing your piquets—or even your sentries—within musket-shot of a wood or any other cover, especially if your own position affords little shelter. Rather than run such a risk the posts should be drawn closer to the main body. This would appear so obvious a rule as scarcely to need being laid down; but those who have read the accounts of the civil war in America will remember how utterly—and how fatally—it was disregarded at Edwards's Ferry or Ball's Bluff. How any man calling himself a soldier could draw up his force in an open field surrounded on three sides by a wood, and an unfordable river in its rear, passes all comprehension! It is an additional proof of the necessity of teaching even the simplest and most self-evident rules of war.

I have already said that no piquet is to shut itself up in a house without orders, unless indeed this offer the only chance of escape. Let me now add that it is not prudent, when near an enemy, to allow your piquet to occupy buildings even with easy egress, as it gives the men too great a feeling of security, and tempts them to relax their vigilance. Where the inclemency of the weather renders shelter necessary, the largest building and nearest to the line of sentries must be selected for occupation, and the unavoidable risk guarded against as far as may be by increased watchfulness.

But where a building commands the position to be defended—whether it be a bridge, or a defile, or an important road—then it must, of course, be occupied, and loopholed and otherwise strengthened for defence, care being taken to leave or to make sufficient outlets for the retreat of the little garrison. In the campaign of 1813 in the Pyrenees several instances are recorded of the successful defence of bridges by single companies against greatly superior numbers by a judicious occupation of the adjacent houses.

The late Sir William Reid, of the Engineers, who was attached to the Light Division during the campaign, bears testimony to the value of the skilful strengthening of his post by an officer on piquet. "It deserves to be recorded," he says, "that the outposts of the 52nd had been so well fortified by a captain of that regiment, that the piquets had no occasion to retire until they had expended their sixty rounds. This officer had taught himself how to strengthen posts by barricades and other temporary expedients, and he deserved the support he always received from the Engineers, who supplied him with what he required from their small depôt of entrenching tools. The piquets being thus enabled to hold their ground without risk for a considerable time, the troops for the defence of the position had full time to assemble (for it was December, and they were scattered in houses), and to deploy on the position. . . . . There was nothing," he adds, "in the defences which impeded the usual formation, and everything was prepared to maintain the ground offensively."

This last paragraph is high praise, for it shows with what skill and judgment the post had been strengthened. I have made this somewhat long extract because the passage struck me as being singularly instructive and encouraging to young officers, for whom, from the opportunities of individual distinction that it holds out, this service ought to possess peculiar attractions.

In the discharge of outpost duties, happily for the cause of humanity, certain rules are recognised by all civilised nations which greatly mitigate the horrors of war, and give to this branch of warfare quite a chivalrous character. The absence of this generous spirit in the hostilities now carried on in America gives them a peculiarly painful aspect in the eyes of military men; but it is in the very nature of civil war, embittered by personal enmities and conducted by undisciplined levies, that a feeling of mutual exasperation should arise, happily unknown to those whose only motives for fighting are duty and honour.

In the Peninsular War, where these mutual courtesies were carried to a greater height than ever before, it was an understood thing that the outposts of an army were not to be attacked except with the ulterior view of surprising the corps which they covered, as, for instance, in Sir Rowland Hill's surprise of Gerard at Arroyo de Molinos. This mode of warfare was not, however, quite intelligible or satisfactory to some of the members of the sister service. When the well-known "Charlie Napier" came from his ship in the Tagus to the lines of Torres Vedras to visit his still better-known namesake in the Light Division, he saw a French sentry quietly pacing up and down at a couple of hundred yards from the British lines. "Who is that fellow?" he asked of his companion. "A French sentry," was the reply. "A Frenchman!" exclaimed the sailor in amazement, "why don't you shoot him?"

Doubtless all my military hearers will remember that the "entente cordiale" between the British and French piquets led, at length, to an order from the Duke peremptorily forbidding all friendly intercourse for the future. And, indeed, it was high time, when the field officer on duty on going his rounds found the posts deserted, and the piquets of both sides carousing together.

The limits wisely imposed upon a lecture by the rules of this Institution have obliged me to omit many of the minor duties of outposts, and to pass lightly over others of more importance. The subject of patrols I must leave entirely untouched. Time only permits me to call attention, as briefly as possible, to the duty of commanding officers to instruct those under their command in this important branch of their professional education, and to point out in what manner this may best be done.

I am well aware that in our service comparatively few facilities exist for this instruction. The detached duties of our army often debar a regiment, for years together, from the advantage of taking part in field movements on a larger scale than those of a battalion, while the enclosed nature of the country around most of the stations occupied by our troops at home renders the light infantry drill even of a battalion a matter of difficulty. In a barrack-yard the practice of light infantry movements is most unsatisfactory; that of outpost duties is simply impossible. Yet, in the ordinary course of service, every regiment must, from time to time,

find itself at some station where these duties can be put in practice—especially since the formation of our camps of instruction—and, even under the most adverse circumstances, much may be done where the commanding officer really knows his work, and feels an interest in it. In the most strictly enclosed countries the highways and byeways will still afford him the means of teaching the military occupation of a country, and from some commanding position he will be able, at least, to point out to the piquets the line on which their chain of sentries should be posted.

Something may also be taught of theory. If a commanding officer would from time to time read over with his officers some work on military science, or some well-written narrative of a campaign, following the movements of the armies on the map, explaining, and inviting discussion, he would, I am sure, find the study both profitable and interesting—to himself as well as to the majority of his officers. It would be too much to say that he would be able to interest all, however well he might perform his task; but, without being too severe, I think we may say that the soldier who can feel no interest in the pages of such a work as Napier's has mistaken his profession.

If we look into the early history of our greatest soldiers—Wolfe, Moore, Wellesley, Colborne, and others whom I could name—we shall invariably find that before they rose into eminence, before they were called upon to take part in active service, they were remarkable for their attention to their regimental duties, and for their earnest study of their profession. Who can say how soon our fitness for our work may not be brought to the test of practice? Let their example be both an incitement and an encouragement to us to improve our present leisure; and let us take for our rule the maxim of the Great Frederick, that "it is the duty of every good officer to know war before making it, and then to apply himself to put his science into practice."

NOTE.—To those who wish to study this most interesting branch of their profession, I would recommend the following elementary works:—

Lallemand's "Operations Secondaires," which has been translated into English by Colonel Sir Thomas Troubridge, Bart., C.B.

Decker's "La Petite Guerre," which has been translated into French and English.

La Barre Duparcq's "Eléments d'Art Militaire."

And Captain Hauer's "Feld Instruktion," published at Olmütz in 1852, and to be found in the Library of the Royal United Service Institution. Besides these, there will be found in the index at the end of the Catalogue of H.R.H. the Prince Consort's Military Library at Aldershott, the names of numerous excellent works on this subject by writers of all nations, some of them of very recent date. But the most useful, and certainly the most interesting, course of study will be, after learning the first principles of outpost duty in some of these elementary works, to read carefully the history of such campaigns as best illustrate this mode of warfare, example being always more instructive than precept.

Sir Edward Cust said :—

In rising to propose the thanks of the audience to Colonel Wilbraham, I regret that he has not included the outpost duties of cavalry. The duties of the two services are so distinct, that almost all that has been said on the subject of infantry outposts would, to a light cavalryman's ear, appear to be that of in-posts. The duties of cavalry outposts are carried so far forward that I have been myself employed one hundred miles in advance of the British army on outpost duty. It so happened that I had the good fortune to sight the whole corps d'armée of Soult in their retreat from Cadiz, from an eminence on the Sierra Morena, when the British army were in quarters about Madrid. Outposts to an army have been likened to the senses of the living body. They are eyes, seeing far ahead into the darkest obscurity of the distant foe. They are ears, for not only do they hear the tramp of advancing troops, but they learn their number, their objects and intentions, their proportions, and the quality of their composing arms. They are the touch also, for they sensitively stand to avert the sudden and confusing shock of war, affording time and space for discipline and organisation; and for the other senses we may say, in the magnificent language of Job, "He *smelleth* the battle afar off, the thunder of the captains, and the shouting." It has been justly stated by Colonel Wilbraham, that the study of outposts is too much neglected amongst ourselves, and that the German cavalry showed themselves superior in these duties to the British, and were so considered by Wellington. There is, however, a little error as to the extent of this remark The German hussars, when they arrived in the Peninsula, were already old campaigners, whereas the British cavalry had scarcely smelt powder for fifteen years. The Germans were experienced hands, but they did not in fact form part of the Light Division, but they were always brigaded with a British regiment, and in this manner I have often also myself formed part of the Light Division. The Germans were, indeed, originally selected on a better principle to render them as a separate corps efficient upon outpost or any other intelligent duties.

The conscripts in Germany were never allotted to the hussar regiments in former days upon the principle that Saul was made a king because he was higher than his fellows, as we generally choose our light dragoons; but men of a superior social condition and education, though they were as small in stature as King David, were chosen for the purpose of hussars. Where men are obliged to act so independently of one another, as a light cavalry man must do, he should have some natural genius for war and all his wits about him. The Germans have, however, a merit that our men could never attain to: they regarded their horses as part of themselves. If they were ordered on a duty at two in the morning, they were stirring an hour previous, giving their *better halves* provender, and getting themselves a cup of coffee; whereas our fellows snoozed to the last moment, and, when roused for the "turn-out," just kicked up their horses, and got upon their backs,—the consequence of which was, that in a couple of hours both men and horses were knocked up, while the German hussar was good to the *mittagessen*.

The study of outposts belongs to every soldier, and I am sorry that there are so few young officers present, for it is not only that the light

infantry system should be learned, or the outpost duty explained to officers of each particular arm, but the staff officers would do well to inform themselves on this subject. I know not whether they form part of the instruction of the Staff College, but they should do so. A matter occurred in my own history in which I might have been seriously compromised by the ignorance of a staff officer. At the river Alva, in Portugal, after Massena had during the whole day checked upon its banks the advances of Wellington's army, he destroyed the Pont d'Alva, and pursued his retreat. This river was an exceedingly violent stream, having a bottom of pebbles as big as boulder stones, and our guide was frequently nearly drowned, or fell up to his armpits, and our horses also were in great danger at every step, in crossing the ford. A staff officer took a piquet of the 16th Light Dragoons, of which I was in command, across this impassable barrier, and posted us on a height above the river, with no other instruction than a "Good night," and then took his departure with his guide. I, of course, immediately went forward with a patrol, and took some prisoners and deserters, who might have afforded useful information; but I had no possible means of passing them across the river to carry back information to the officer in command of the advance, nor of getting away myself, if a hostile patrol had come against me.

The necessity of a superior class of individual soldiers for cavalry outpost duty was singularly exemplified in another event of my own history. When Wellington was about to cross the French frontier in 1813, he issued strict injunctions that the greatest vigilance and circumspection should be exercised by the piquets and patrols. Having become an experienced outpost officer after three years' unremitting work, I was charged with one of the first patrols that entered the French territory. I accordingly left the lines with about twenty-four men, all having their swords drawn excepting the advance and flanking dragoons on either hand, who rode with loaded carbines. After pursuing the high road for a mile or two, a considerable village took my attention, and I left the advanced dragoons in vedette, with the most peremptory orders for caution, and descended to the place, where I neither dismounted myself nor allowed the men to enter a single house, but sent for the authorities to come to me, and obtained from them the information I desired, and I then returned to the high road. Conceive my embarrassment when I found that my vedettes were gone. Supposing they had been surprised and enveloped by the enemy, I retraced my steps to the lines, where I astonished my comrades at my speedy return, but they could afford me no news whatever of my missing vedettes. I accordingly returned to the spot where they had been posted, and after a long search of every house in the vicinity, I found them dead drunk in a farmyard, to which they had been enticed by a farmer who wished to show his favour to the British by this act of hospitality. I need scarcely say that we were treated by the French inhabitants on the north of the Alps with the same attention as had ever been shown us in Spain, where it was often my fate to pass days and even weeks in the houses of the people, and especially the priests, without the expense of a single milrea or the apprehension of any personal danger.

Drunkenness is, sadly enough, the prevailing vice of our race; but it is

infinitely more sad to see it so common among our soldiery, because there are no troops in the world who so little need a fillip or the excitement of drink to induce them to do their duty and front the post of danger.

Colonel Wilbraham has expressed his regret that want of time did not allow him to go into the subject of patrols, and I would add my regret at this also, and that it did not allow him to go at greater length into the consideration of skirmishing. I think this is a matter not thoroughly comprehended by our people. As I understand its purport, it ought not to be regarded as an offensive act—at least it is not so in cavalry outpost practice. The object of skirmishing is to protect formed bodies from individual insult. When two opposing bodies face, an officer might daringly dash at the leaders of the opposing force, or fire at random some revolver or other offensive arm into the serried ranks, and not only cause casualties, but offend the susceptibilities of the troops. This is prevented by placing a rank of skirmishers between the troops in formation on both sides, as was wittily remarked on another matter, "comme un sac de coton entre deux vases de porcelaine." Again, skirmishers occupy the attention of an enemy while the larger operations intended are getting ready. It was my fate to be upon one of the longest skirmishes on record. On the night preceding the battle of Salamanca there was a dreadful thunderstorm, which frightened the horses in our bivouac, who broke loose, and scampered wildly over the country, the dragoons running after them to catch them. I happened to have secured my charger, and accordingly, on an order arriving for a piquet, I went with such men as I could collect. The storm passed over, and after a fine night the day broke, exposing the enemy right before me. It was about four in the morning. I immediately carried my men forward as skirmishers, and so continued on this duty till nearly eleven in the day, when I was called in to join my regiment; but I found it had been moved to the extreme right flank of the army. Thither I followed, and reached it at the moment when the advance was actively in motion to attack the Arapiles. I continued in rapid advance until the battle was ended at two o'clock in the morning, having been twenty-two hours on horseback. My horse died of the fatigue before the turn-out sounded next morning.

I have now to request the usual expression of your thanks to Colonel Wilbraham for a lecture not only most interesting in itself, but very clearly and intelligibly enunciated, and pleasantly illustrated. Our thanks are especially due to an officer of his rank and standing in the Army, because we must all appreciate one's own natural unwillingness to put oneself in the lecture seat, in opposition to all our habits, merely for a public good; but it is the more valuable to us, and yet more deserving of our thanks, when officers of reputation will attend to this duty, as setting an example to other officers of distinction and ability that I hope will be followed in this Institution.

LECTURE.

Friday, January 31st, 1862.

Major-General W. WATKINS in the Chair.

AN OUTLINE OF STUDIES RECOMMENDED TO A YOUNG OFFICER.

By Col. W. H. M. Dixon, R.A. Superintendent Royal Small-arm Factories, Enfield.

It has been said that "Military habits and organization are conducive to the best interests of society, even during a period of profoundest peace."

Accepting this statement in its evident meaning, viz. that perfection of discipline, training, and education in military men reflects not only honour and renown upon themselves, but is the true safeguard for the public weal, it will be my object to show to my younger brother officers how universally this truth is acknowledged, by what means its accomplishment is sought for in foreign armies, and how it can be obtained in our own.

Incidentally I must also touch upon the education, in some respects, of the soldier, as having a certain connection with that of the officer.

It is quite unnecessary for me to cite examples of the benefits conferred upon countries, and even the world at large, by accomplished and successful generals, or to point out the opposite results entailed upon kingdoms and empires by the weakness and ignorance of those military leaders to whom great interests had been committed.

Warfare as conducted by civilized nations is more dependent upon the results of scientific arrangements and combinations than upon mere physical or brute strength.

The object of a war is undoubtedly to cripple or destroy the material forces and defences of the enemy; but the general who accomplishes this object with the least loss to his own army is acknowledged to be a master in the art of war.

We can easily see the force, and acknowledge the correctness, of the statement of a French writer, who says that battles are the mere accidents of modern civilized warfare. For instance, two armies entering the field

in opposition to each other will eventually endeavour by a system of well-considered manœuvres to obtain possession of some point the occupation of which will exercise some very decided influence upon the results of the campaign.

On the supposition that both armies are equally well handled, and each has an equal start, if we may so call it, the probabilities will be that the operations of both armies will finally lead to a battle in order to decide upon the possession of this point.

On the other supposition—and the most natural because the most common one—of a difference in the quality of the generalship of the two armies, then it would most probably happen that the army best commanded would succeed in securing this objective point without the necessity of a battle, and, if so, would have secured a double advantage.

Again, the most skilful generalship is required at times to avoid the risk of being drawn into action upon unequal terms, or upon unfavourable ground.

On the other hand, to choose his own time, to manœuvre skilfully and confidently in presence of an enemy, and finally to take advantage of a faulty disposition to strike his blow, is the mark of a consummate general and accomplished soldier. I could not cite a better example of this than the lengthened manœuvres which preceded the battle of Salamanca fought by the Duke of Wellington on the 22nd July, 1812.

These illustrations will sufficiently explain the meaning of the statement that "those great military scenes which we designate by the name of battles are more the accidents of warfare than its principal or leading objects."

Having thus thoroughly imbued ourselves with the feeling of the importance to be attached to true generalship, we have only to agree to the proposition that there are no "heaven-born" generals in order to grapple fairly with the subject before us this afternoon, and to consider the description of studies necessary for a young officer to pursue, in view of his advancement to and employment in the highest ranks of his profession.

By the term "education of a young officer," which of course is the result involved in the studies recommended to be pursued by him, I understand not only the professional training required to be gone through to fit him for the varied military duties he may have to perform as a matter of duty, but also the developement to the utmost extent of all his faculties and energies towards the attainment of honourable distinction in his career.

In setting out with a high standard I do no more than any member of the learned professions might be expected to do, and whose example should hardly require to be much insisted upon by me in laying down my argument.

One supreme conviction ought to weigh with every officer who receives a commission, viz. that it is a trust committed to him by his country, a confidence reposed in him, and for no selfish or individual ends.

From this conviction springs the sense of duty as an incentive to action, and this is emphatically the lever which I must employ, as others have before me, to stimulate my younger brethren to exertion.

Well, then, if we start with the conviction that some military study is

necessary for every officer after he has entered the profession of arms, we may also lay down as a rule that successful study will be honourable to him.

It is worthy of remark that the periods at which scientific military education has most engrossed the attention of the great military monarchies of Europe are those in which great military operations have brought into strong relief the wants of the different armies engaged. During and after the Seven Years' War (a period which saw much of the present military schools and colleges spring into existence), the French Revolutionary war, and more recently the Russian war, the student of military history will see how indefatigably endeavours have been made to improve the education of the officers of the army.

Since the termination of the war with Russia, the whole public voice of England has called for a better education for our officers, and particularly for the staff of our army. The deep interest which the general public feels in the result of any war in which our country may be engaged makes them feel all the importance of having the fortunes of the country committed to able and competent heads as well as strong arms. If we turn to the Memoirs of Frederick the Great, we see the same anxious solicitude for the proper training of his officers, and the same complaints upon the inefficiency of his staff.

At the termination of the Seven Years' War he writes: "The position of the soldier may be left as it was before the war began; but the position of the officer is a point to which I am devoting my utmost care. In order in future to quicken their attention whilst in service, and to form their judgment, I have ordered them to receive instruction in the art of war, and they will be obliged to give reasons for all they do. Such a plan will not answer with every one; still, out of the whole body, we shall certainly form some men and officers who will not merely have their patents as generals to show, but some capacity for the office as well." And, again, in describing the difficulties in the way of impressing upon the minds of his young nobility the necessity for military study and training, he says: "They shrink from the army because it is a real training for the character; nothing is passed over in a young officer—he is obliged to maintain a prudent, regular, and sensible conduct. This is precisely what they dislike, and one hears the absurd and insolent expression, 'If my boy will not work, he will do none the worse for a soldier.' Yes, he may do for a mere man-at-arms, but not for an officer fit to be advanced to the highest commands, the only end of a good soldier's life, and which requires really extensive knowledge."

What Frederick the Great was then anxious for—what France and the other great military monarchies of Europe have, by different plans and with varied success, been striving after—viz., the highest degree of education capable of being imparted to an officer—presupposes, as a rule, a condition of obligatory work on the part of the officer. It is necessary for me to touch upon the objects sought to be attained by the obligatory system, and the results arrived at, as showing what is considered necessary for an officer to know, and how this knowledge is expected to prepare him for filling with credit the higher branches of his profession.

In the early part of 1856, a commission, composed of two officers and

a civilian, was appointed by the Secretary of State for War, "to consider the best mode of re-organizing the system for training officers for the scientific corps."

The commission furnished a Report on the specific subject to which their attention was directed, and also added to it "An Account of Foreign and other Military Education." This Report has been published in the form of a Blue Book, and contains the most interesting mass of information upon the subject of military education that has ever been collected together.

I intend to employ this Report as my text-book whenever I appeal to what is going on abroad or to the opinions of foreign military savans.

FRANCE.—In France there is a very broad distinction drawn between the requirements for an officer of the scientific corps and an officer of the line; for, while in the former case every endeavour is made to impart very high mathematical knowledge, in the latter a very moderate amount is considered sufficient. Let us take, for example, the Military College of St. Cyr. A fair, but by no means extensive, knowledge of mathematics is required for the entrance examinations only into this college. With the exception of some lectures on descriptive geometry and physical science applied to military art, the main teaching consists of military art and literature, history, geography, military statistics, fortification, and modern languages.

The whole system of instruction in this school is of a highly practical and useful nature. Young men intended for the cavalry are instructed in infantry and artillery movements and drill; just as those intended for the infantry are taught riding, and receive instruction in cavalry, as well as artillery drill and movements. This is considered a most important part of their instruction. "It is this," said the General Commandant, "that made it practicable, for example, in the Crimea to find among the old *élèves* of St. Cyr officers fit for the artillery, the engineers, and the staff; and for general officers, of course, it is of the greatest advantage to have known, from actual study, something of every branch."

I think that the system at St. Cyr shows more truly the peculiar military genius of the French nation, and what is required for an officer's education, than that at the Polytechnic School. At this latter there is a mixture of the military and civil elements; the higher prizes are those for the civil departments of the Government; and the traditions of the school, together with the high standing of its many distinguished scientific *élèves*, have all tended to keep up a very high mathematical standard, to the exclusion of literary and classical studies.

Agreeing that mathematical knowledge is necessary for the scientific corps of the army, and that it is a good educating agent for the mind and judgment, I am not at all convinced that the process of intense and almost exclusive application to such a study is one either called for by any branch of the army or calculated to make what is required—viz., a practical, as well as a theoretical, soldier.

It is even a question among distinguished French officers whether this process, as pursued at the Polytechnic, is not an exhaustive one to the brain of many of these young men, and injurious to them eventually. Excessive mental, as well as physical, training produces similar results;

and while in the Army we may for particular services require a better and more elaborate educational training than for others, yet in both the condition of a healthy, vigorous, active bodily frame is a *sine quâ non*.

The French may justly regard the Polytechnic as a great national institution—superior, very possibly, to anything of the sort in the world. But we must bear in mind that it is not purely a military school, and that very frequently those who get into the Artillery and Engineers are the lowest qualified of that school.

Staff Corps.—The entrance into the staff corps in France is through the school of application for the staffs, and the twenty-five annual vacancies in this school are filled up by three pupils from the Polytechnic and by a competitive examination between the pupils of St. Cyr and second lieutenants of the army. The vacancies mostly fall to the share of the pupils from St. Cyr. This at once opens out a wide career for an intelligent and ambitious officer. Once he is attached to the staff, from the result of a two-years' successful study at the staff school, he permanently belongs to it.

The course of study is worthy of remark, as combining in a high degree all the essential elements which constitute an efficient staff officer. They are: descriptive geometery, astronomy, topography and geodesy, geography and statistics, artillery, fortification, military art, military administration, manœuvres, German, drawing, keeping of memorandum-books, conduct and discipline, riding and knowledge of the horse. The work is done to some extent out of doors—such as military sketching; making plans of country, with and without trigonometrical points and distances; and plans of fields of battle, with descriptive notes and remarks.

It is worthy of remark that in France not much value is attached to any but compulsory study or training.

In their military schools we find that the young men do not study much by themselves. Whatever lectures they attend and take notes of are subsequently carefully and systematically gone over with them by a set of instructors, called, from their office, *répétiteurs*. The great object is to give their officers, or that portion of them who do not rise from the ranks, a careful professional education.

In the Artillery and Engineers this is principally given at Metz, and an extensive practical training is given to these officers after they enter the service, first by their remaining with the troops until they attain the rank of second captain, and subsequently being employed in the arsenals, workshops, and fortified places.

A short account of the regimental schools for the artillery and engineers of the French service will be very interesting, as bearing considerably upon the direct subject of my lecture.

These regimental schools are intended for the instruction, both theoretical and practical, of officers, particularly those promoted from the ranks, non-commissioned officers, and private soldiers.

It must be borne in mind that a considerable number of officers rise from the ranks in the French service, and consequently have much to learn theoretically after getting their commissions. These schools therefore have a particular significance, as showing that the French soldier when

raised to the dignity of an officer is not left without further means being provided him for obtaining a good education, and thus qualifying him for pushing his fortunes without any limit beyond that of his own intelligence and desire for advancement.

In Marshal Vaillant's report to the Emperor on the organisation of the Imperial School of Application for the Artillery and Engineers at Metz there occurs the following passage:—

"I beg to call your Majesty's attention to the dispositions of Article 65 of the Decree, by virtue of which any officers of the artillery and engineers promoted from the rank of non-commissioned officers may be authorised upon their own request to share in the instruction given at the School of Application. It has seemed to me that the whole career of education ought to be opened to officers who, being less favoured by fortune than their companions, have not received the same advantages of instruction before entering the service."

The regimental schools may be therefore considered as stepping-stones for this class, and also as furnishing the practical instruction in their profession to those officers who join their regiments from the School of Metz.

The instruction is broadly divided into two distinct portions, viz., into summer and winter instructions, the former comprising the regimental instruction, or that which exists in the interior of the regiments, and which is directed by the chiefs of those corps who are responsible for it, with the means placed at their disposal, under the general surveillance of the commandant of the school; and the latter, or winter course, which requires the assistance of the special means of the schools, or the employment of its professors and *matériel*.

To a considerable extent the instruction is imparted by officers of the two corps, and particularly to the classes of non-commissioned officers and privates.

A professor of mathematics and fortification is attached to each school. At the end of each course general examinations are held, and lists made out in the order of merit, with notes of the capacity and aptitude of each of the non-commissioned officers and men; and these lists are consulted in the formation of tables of promotion.

It is not to be supposed, however, that no professional teaching is given to officers of the line or cavalry after joining their regiments. The following circumstance will partly show how this is attended to, and tend still further to exhibit the system of careful systematic instruction given to officers upon subjects which are peculiarly within their circle of duties.

I was travelling with several young officers on a professional tour on the Continent, including, besides, an inspection of fortified places and battle-fields and a visit to the French camps of instruction.

At one of the camps, I was inquiring about the instruction given to the regimental officers in the manœuvre of a brigade and division, and how it was accomplished. I was told, that, previous to the brigade drill of the ensuing day, the regimental officers were informed of the nature of the movements it was proposed to execute, their object, and how they were to be carried out. A sketch or plan of the movements was drawn up, and every young officer had the subject explained to him in a kind of

regimental meeting presided over by the commanding officer, the latter having had the information from the general of brigade. Instead, therefore, of any movements being executed *à l'improviste*, or without due consideration, the whole subject had been previously discussed, and each manœuvre shown to be *à propos* to some object, or subsequent change of front or deployment. The camp was thus made one of positive instruction; and so systematic is the French military system on all subjects connected with the efficient drill, on *intelligent* and *intelligible* principles, of the officer and soldier, that the drill of the brigade is completely mastered by all concerned before the divisional drill is allowed to be entered upon.

May we not be allowed to account for the acknowledged superior intelligence in all military matters of French soldiers, and their love for discussing and criticising everything connected with professional subjects, by this system of giving rational explanations of the nature and object of military movements to all ranks, and thus enlisting on the side of well-considered and skilful combinations the intelligent appreciation of the mass? Is there any good reason why such a system, carried out even further, should not be introduced into our own service? I do not know that it would be advisable, on many grounds, to occupy a soldier's spare hours of an evening for such lectures or professional discussions, but an occasional alternation of a lecture instead of a drill would tend to vary the monotony of a camp life, by introducing a different subject to the notice of the soldier, and addressing his intelligence on points which are to be made the matters of actual practice.

I have no wish to force attention too much to the condition of the army in a neighbouring country, but I cannot help alluding to the physical education which is going hand in hand with the intellectual.

To an Englishman, who generally dislikes anything systematic, and whose natural bias is shown by a studied independence and individuality of act and thought, it may seem a strange spectacle, the attempt to develope by a progressively systematic method the physical powers of a large number of men, and for objects which are not immediately apparent.

And yet, according to recent accounts, most surprising results are being obtained by gymnastic drill or exercise on a very large scale, and its popularity is unquestioned.

Gymnastics of the French Army.—Mr. Steinmetz has given to the Institution a most valuable paper on this subject, and I cannot too strongly recommend every officer in the Army to procure a copy of the printed pamphlet. For both officer and soldier a physical training is pursued on a plan which must commend itself to every intelligent mind. These exercises to some extent take the part of drill; and, in fact, are preparatory to ordinary recruit drill.

The old Prussian system of setting up a recruit and teaching him to march, is superseded by one which is to teach him the full powers of his body, and so enable him to make use of his professional knowledge to the best advantage.

It would be of no advantage to a regiment composed of the most scientific men in the world to know that they ought to occupy a certain position, if, from defective training, a small amount of extra exertion had

incapacitated them from the capability of making the effort necessary to reach that position.

This simple truth lies at the bottom of all the improvements which are taking place in the French Army, and which to some extent were strikingly exhibited in the late Italian campaign. I allude to the celerity of movement and rapidity with which the French soldiers closed with their enemy.

I should not have satisfactorily terminated my short account of French military education, had I omitted to notice the physical education as a portion of their system. Depend upon it, that no nation can afford to neglect this most essential point.

To officers of the English Army, who are as a race passionately fond of athletic sports, and pre-eminently distinguished in them beyond any other nation, this lesson must not be thrown away. You will as a rule have to depend in the field much more on the physical powers of your men than on their intelligence. The latter it will be your province to guide and instruct; the former must have been the result of careful training, and cannot be remedied at the decisive moment, if defective, by the best will on your parts.

I really do not see why proper instruction in some central gymnasium should not be afforded to a certain number of non-commissioned officers from the various services, on a principle similar to that adopted in the French Army; and thus a good corps of Instructors raised for the Army, who should be under the supervision of some central control, similar to the Instructors of Musketry in their relation to the Commandant at Hythe.

I think every one will agree with me in the feasibility of the scheme, and, that it would become an exceedingly popular diversion, as well as drill, amongst the soldiers of the army cannot be doubted by any one. Yearly exhibitions might take place in regiments or camps of the results of this training, and small prizes awarded to the most proficient. I think that this proposal would tend to improve the army physically, and morally also, as it would soon discover the drunkard, the dissatisfied, or the sulky man. Such games, as the results of careful early training, were very successfully commenced and conducted by Colonel Eardley Wilmot, when commanding the Cadet Company at the Royal Military Academy, Woolwich. This physical development seems also to be wanted as a supplement to the high training in the use of the rifle which soldiers now receive. The two combined would make the perfect soldier.

In confirmation of these views, and as affording a striking illustration of the evils to be anticipated from a want of proper physical training, I would point to the disaster which befel the American Federal army at Bull's Run.

The "Times" of the 29th instant contains a leading article on the report of the Sanitary Commissioners appointed by the Federal Government to the head-quarters of General M'Clellan's army. This report states emphatically that a want of physical training and ability to bear the ordinary hard work of a soldier in the field was one of the causes which led to the severe losses the army experienced.

There does not appear to have been anything extraordinary in the amount of fatigue demanded from the soldiers of this army, and they had

not been exhausted by previous long marches or an active campaign, but, as the "Times" says, "It was their very first rapid march and the first loss of a meal which rendered them helpless and unfit for the work of a battle. Here lies the true secret of the whole affair. The men were only soldiers of three months' standing. They had never been inured to privation or even inconvenience. They could not carry their packs and muskets comfortably for a short march on a cool morning, least of all could they stand a mile or two at the double, which, indeed, might have tried older soldiers than they were. The consequence was, that when they got to the field, though with *good training* and *good arrangements* they ought to have been fresh as larks, they were in no condition to do themselves justice. They were brave enough, no doubt, and had will enough to fight, but they had none of that endurance which *training* alone can give."

In strong contrast to this, we have only to turn to the famous march of General Crawford's light brigade, which joined the Duke of Wellington after the battle of Talavera, having marched sixty-two English miles in twenty-six hours. Here is an example of what real soldiers could do in those days.

I do not think it necessary to describe similar, though not such energetic, efforts to educate the officer and soldier in Prussia and Austria as in France. The aim is in most respects the same, although the method is different, and the material to be worked upon varies very much from the impulsive, energetic, and reckless Frank.

The subjects, however, which form the staple for the professional training are identical, and are such as I shall have to touch upon presently.

I cannot, however, avoid inserting a portion of a Report of a mixed commission of military and scientific men presided over by General Lützow, as alluded to in the Blue Book from which I have already made several extracts.

"Instruction in pure mathematics in the military academy, particularly in the lower classes, must be considered one of the most important branches of teaching, not merely because the chief points in military science are founded on mathematical principles, but still more because a profound study of mathematics accustoms the head to clearness, accuracy, and method in thinking."

Again—"Geography, history, and statistics are the sciences by the study of which a young man comes in connection with the world before he knows it practically."

So again as to physical and historical geography—

"It is here particularly that, whilst we give the soldier a sufficient knowledge of preparatory science, we should point its application to the business of war.

"Without war, to gain some knowledge of war beforehand, to accustom the mind to throw itself as it were into the most perplexed circumstances of war, and to see what principles are to be applied to them, is certainly a great object in military science. Military geography helps us to do this; first, because without it the operations and conduct of a war are not intelligible; secondly, because the thorough knowledge of a country, both in its inhabitants and its physical geography, helps us to conceive the

course which any future war will take, and the best mode of conducting it. The first is the more elementary, the latter the higher practical and strategical, branch of the science. And this last requires so much thought and knowledge as to make it undesirable to teach it in a higher school. It should form the employment of a staff school. But detailed suggestions are given for a course of the simple kind of military geography."

That a high degree of professional education is considered necessary for an officer, is clearly shown by the accounts I have given of the system pursued for that object in France; and Prussia, Austria, Sardinia, and Russia are all engaged in improving military education. In fact it must march with the times, and advance at the same rate as general education and intelligence advances.

In our own service, with the exception of the Artillery and Engineers, the continued education of the officer, apart from the direct professional duties required from him, such as drills and field manœuvres, has not been hitherto attempted. The only school at present for officers is the Staff College, where a limited number obtain the information requisite to pass the examination for the staff. This appears at present to be the only test of professional excellence, and the only way to arrive at distinction in times of peace. This being the case, I almost think that the prize of a staff appointment should be made in a pecuniary sense a more valuable and a more permanent one.

The great mass however of our officers are left to themselves either to work out their education from individual predilections, or else to rest satisfied with that amount of professional information which will enable them to go through their ordinary duties without bungling.

I think that, if the matter were fairly and properly brought before the army at large, our younger officers would recognise at once the extensive range of information which ought to be mastered to a considerable extent before correct ideas can be entertained even upon merely professional points; and thus the want of a sufficient motive for further education would be satisfactorily met.

Whether in peace or in war, the officer who had tried to mature his judgment and cultivate his reflective powers, other things being equal, would certainly come to the front, and soon bring himself into notice. Is not this a motive strong enough for a military man?

The formation of camps of instruction in various parts of the United Kingdom is most favourable for carrying out any general scheme for the education of the officer, as the means or apparatus necessary to be provided could be better obtained for a large than for a small number.

The instructors would also have the advantage of illustrating their lessons by the actual exhibition of considerable bodies of men under manœuvre. It is possible also that sound criticism in relation to tactics and the method of handling troops under certain suppositions, and of occupying ground, might beneficially re-act upon older officers, and induce greater circumspection and consideration in arranging for the general drill and manœuvres of a brigade or division.

At first I would therefore recommend that young officers be brought together for the purpose of going through a course of reading on military subjects, such as strategy and tactics as taught by the best military writers.

If the subjects can be treated in the languages in which they are written, so much the better, but this at all events might be pursued with a few who were found competent and expressed a wish to do so.

Special histories should then be selected, which illustrate from actual campaigns the principles contained in the first subjects.

These histories will touch upon the three arms, their combinations and employment, with the special tactics of each arm.

Military topography, as a most essential element of instruction for all military men, will naturally engage a good deal of attention. It forms a very attractive subject for teaching, as it is so intimately connected with all military movements, and the works which treat of it in a military sense are profusely illustrated with examples of movements of armies guided as well as determined by the topographical features of a country. I think that no one could follow up this subject for any length of time without obtaining a large amount of collateral knowledge on military matters of a most useful as well as interesting nature.

Plan-drawing and field-sketching, with reports upon routes of communications, could be exceedingly well taught at the camps, and their usefulness and importance prominently brought into notice.

With the latter should be associated such elementary information upon geology as will enable an officer to describe the features of a country correctly, and to give other and valuable information dependent upon its geological formation.

A knowledge of the ordinary instruments employed for field-sketching can be obtained with little trouble, and particularly if combined with out-of-door practice at the same time.

The elements of permanent and field fortification would naturally form part of such a course.

The subjects enumerated are all purely professional, and such as can be easily acquired by any one who has the will and determination to make them his study. It remains now for me to show how this can be done, and to point out those authors whom I would recommend to be read and studied on the art and history of war.

Restricting myself still to the camps, I will suppose that military libraries and rooms or halls for study, drawing, and other purposes, are established there.

These means may possibly be afforded at the public expense, and should be supported by some small contribution from the officers in camp.

A body of instructors could, I have no doubt, be raised from amongst the officers of the three arms in camp.

Their qualifications however to act as instructors should be satisfactorily inquired into, either through the medium of the Staff College or through the adjutant-general of each arm.

The authorities might think it advisable themselves to nominate and pay these instructors; if so, a great point would be gained.

Should this however not be the case, I should think that any request by a body of junior officers in camp to be instructed as a class in any professional subject would meet with a ready response from some who are capable of imparting the requisite information.

In this way a beginning would be made, and pressure gently brought

upon the authorities to provide permanent means for instruction, such for example as are provided in the French regimental schools. I will suppose that the machinery is by some means or other established, artillery, engineers, and staff officers furnishing the instructors.

A class of young officers meet and settle to go through a course comprising the various subjects I have named.

The principal author for selection on strategy, I would recommend to be, without hesitation, the Archduke Charles of Austria; for, although his name does not appear as having *really written* the work on strategy attributed to him, the work bears such evident internal evidence of the fact, that we need not dispute it.

I would recommend this work to be most carefully gone through, each officer making a map for himself, if possible, and following step by step the whole course of the campaign, beginning with the passage of the Rhine by Moreau at Kehl, and terminating with the siege by the Austrians of this latter place. I would advise, although it might appear tedious, that every step in the operations of this master campaign should be traced.

It will thus prove a valuable lesson, and one which will not soon be effaced from the memory, besides giving most interesting topographical and geographical knowledge of localities.

Jomini on Strategy may also be strongly recommended, and employed usefully in connection with the former work.

After studying the principles of strategy, and their application to the campaign of 1796, I would recommend that some of Napoleon's campaigns, for example his first in Italy, commencing with the battle of Montenotte, be examined with reference to the strategy of the campaign, and a memoir on the subject drawn out; or it would perhaps be as interesting to take the campaigns of the Duke of Wellington in the Peninsula, and study them in a similar manner.

Maxwell's Life of the Duke of Wellington is a very good work to be taken for this purpose.

There are numerous examples also to be found in Marlborough's campaigns, including his famous march from the Low Countries to the Danube, ending with the battle of Blenheim, which may well serve as studies on strategical combinations: also the Seven Years' War. In fact, once a student becomes interested in the study of this higher branch of the art of war, the field of research opened out to him is inexhaustible.

For the study of tactics there are numerous foreign authors from whom good selections can be made. It would be well here not to confine oneself too much to one or two authors, but to read several and compare them.

A very elaborate work on tactics, containing a great deal of information and general criticism, has been published from the papers left by the Marquis de Ternay, a French nobleman and refugee from the Revolution of 1789. The work has, I believe, been employed in France as a text-book at St. Cyr, and a high commendation is passed upon it by M. Koch, who edits it, as being a work of great merit, and containing just what was required to form a good text-book on tactics, for teaching this branch of the art of war.

I think, to the English reader, it will be found rather pedantically written, and its style heavy and too dogmatic; but I also think, from having carefully read it, that there is much matter for reflection, and many judicious remarks.

Jomini is much more likely to interest as a writer, and his range is very considerable, extending throughout the Revolutionary War. Portions of his works may be selected to form a course of reading on tactics, and particularly the earlier campaigns of Buonaparte in Italy, which are considered as affording the best illustrations of the tactics of this great master in the art of war.

Templehoff, the historian of the Seven Years' War, and Decker, who has written on the same period (with special reference to the employment of artillery by Frederick the Great), together with General Lloyd's account of the Seven Years' War, may also be considered as valuable authors.

This period is well illustrated by the *Battle of Minden*, gained principally through the instrumentality of the English infantry contingent, by their bold attack on the French cavalry, the finest then in Europe, and showing that a tactical error in the disposition of troops on the field of battle may be productive of the greatest disasters. This error was in the disposition of the French cavalry, placed in the centre of the French army, and not sufficiently supported on their flanks.

Many such errors, and the unfortunate results generally attending them, are alluded to by the authors I have named, and should be specially noted for the information of the student.

Special tactics, such as the tactics of the three arms combined, of each separately, or combined two and two, are treated of in several foreign works. The most noteworthy are: Brunét's Histoire d'Artillerie, combining many notices upon the employment of this arm; Decker, de l'Artillerie à Cheval, avec la Cavalerie; Decker, Trois Armes; Favé, Trois Armes; Decker, Seven Years' War, noticed above, as showing the employment of artillery in that war.

I know of no English author who has treated of these subjects in a similar way, and I am therefore compelled to allude to foreign writers.

Having read these works, I can safely recommend them to any one as giving a variety of most useful information on the combined action of the several arms. Thought and reflection cannot but be stimulated by a perusal of such authors.

To the cavalry officer I would particularly recommend the work by Decker on the employment of horse-artillery and cavalry. He very justly remarks that either arm is the complement to the other, for, while cavalry possesses the offensive and artillery the defensive element, the union of the two arms constitutes the perfect military body, having both elements combined.

The first public lecture I ever gave, I recollect, was on the subject of the manœuvres of cavalry and horse-artillery, and I found this work invaluable as a text-book; I found that I could make the subject, by means of plans and supposed positions of the troops, both interesting as well as improving; nothing could better show the systematic handling of these troops, or at all events lead to correct views being arrived at on the subject, than such a work.

On the subject of general military history, and military literature, I would not wish to restrict the taste of any one by limiting his choice to particular authors. The best are known pretty generally, and good selections could be very well made by the officers instructing.

Some officers would doubtless like to refresh themselves by reading Cæsar's Commentaries again; the Chevalier Folard's Polybius would be within the power of any ordinary French scholar to read.

Vegetius on the Military Customs of the Romans, would prove very interesting. The student would trace almost all the modern customs in camp and on the march to the times of the Romans, and discover that General Crawford's orders for the Light Division in the Peninsula were remarkably similar to regulations in practice in the Roman armies.

However, it is more than probable, that, valuable as such reading would be, time would hardly permit of its being pursued to the exclusion of a tolerably complete course upon more modern military history, relating to operations on ground, and with means and appliances with which we are acquainted, and which to a considerable extent have altered the art of war in some essential particulars.

Topography, by means of the well-known work of La Vallée (which treats of the subject in a purely military sense), can be made a real means for imparting extensive military, as well as general, information. The work should be read, at first, in order to gain a general knowledge of the contents, and then employed as a work of reference in connection with the study of particular campaigns.

The work, as published in an abridged form, and translated by Colonel Jackson, contains the military topography of continental Europe, and as such contains all the information necessary for any one studying the general physical features of any country in Europe with reference to military operations in that country. Of course, it would be necessary, for particular purposes, to have more detailed information, and this can be got by the official maps of those countries; but for all educational purposes this work is sufficient.

At first, I would commence by taking a particular country—France, for example, which, as the author's own country, is probably best treated of. A skeleton map should be drawn, for the purpose of filling in afterwards merely the military topography of the country—viz., the frontiers bordering on neighbouring states, showing the physical formation, the natural and artificial obstacles, water-lines, roads, &c. The lines of fortified places on each side of the frontier would be shown on this map. Particular battle-fields should also be marked, as determining the sites which have been considered both strategetically as well as tactically important.

A knowledge of ancient history would help the student in attaching the proper relative importance to particular places which they have probably always borne—such as Toulouse, the central point of operations for the defence of the South of France, and Lyons, a similar point for the south-eastern frontier.

Again, it would be interesting to mark down in different coloured lines the lines of operations pursued by the various armies which have invaded France, commencing with the invasion by the Prussians at the early part of the French Revolution. A map of the above nature, carefully and

correctly drawn, and with all this information inserted, would give at a glance most valuable and interesting matter for a military man to meditate upon. I shall never forget my feelings when travelling through the Val d'Enfer, or the Höllenthal, in the Black Forest, after reading the stirring account of General Moreau's celebrated retreat through it; or the interest with which I examined the fortifications of Rastadt and the country leading from it up to the defiles of the Kintzig River, which opens a way through the Black Forest for an army to reach the higher Danube, after reading the Arch-Duke Charles's account of the retreat of the Austrian army by this route.

The careful study of this work would most certainly induce the habit of studying country with reference to military movements, either for offensive or defensive operations. The mind, as well as the eye, would become educated to regard military operations as based upon an accurate knowledge of the country which is to become the theatre of them, and hardly anything becomes in this sense too insignificant for the military topographer's notice. I allude to this because some not very thoughtful readers might be inclined to consider that La Vallée goes too much into minutiæ in his details of apparently insignificant obstacles.

Field-sketching would form a very interesting subject, and many officers would soon become quite proficients in this art. The immediate value of such an acquirement would be recognised by all, and, together with instruction in the use of the pocket sextant and prismatic compass, would enable an officer to arrive very soon at the next step—viz., laying down and making reports upon routes of communication, with all the collateral information necessary to be furnished to the proper department which has the charge of choosing roads along which troops have to march in an enemy's country. The highest degree of art in this important branch of duty is when an officer can manage to sketch rapidly and fill in his route from horseback. This requires a practised eye and steady hand; but it is the ultimate point to be aimed at by an officer who wishes to be a proficient in this art.

In order to sketch ground correctly, and give besides as correct information as possible, he should be possessed of some elementary notions on geology. Even a study of heaps of stone on the road-sides is of service, as indicating the nature of the formation in the locality, and giving also an idea of the probable condition of the roads themselves in bad weather, the indication being drawn from the nature of the materials used to repair them.

Every officer who has not had the advantage of a Sandhurst or Woolwich course should consider it a duty incumbent upon him to obtain a tolerable knowledge of permanent and field fortification, and take every opportunity of making himself perfectly familiar with the details of fortified places, and the relations which the various works bear to each other for defensive purposes. Should he travel on the continent, he will find numerous examples to study from, and gain also good notions of the improvement in fortification introduced by the German school of late years.

With respect to the periods of the year to be devoted to study, I would recommend a division similar to what I have described in the French regimental schools, viz. the summer season for the practical and out-of-door work, and the winter for reading, drawing, and theoretical exercises.

General literature, and subjects which, although not strictly professional, are yet portions of every gentleman's education, need not be dwelt upon here. These must be left for each one to select for himself.

My object has been to suggest subjects for study which bear directly on the profession of a soldier, but, in direct connection with all this, there must be a cultivation of other qualities, which are no less essential, in order to allow of an officer making use of his acquired knowledge for the public benefit. I mean that ready decision of mind and firmness of execution, which may be called by the name of promptitude, and which, together with knowledge—or, which is the same thing, power—goes far to make a perfect soldier.

If we think of these two qualities, viz. promptitude and power, as summing up in a general way all that I have said on intellectual and physical education, we shall see by a process of analysis all that is necessary to arrive at the possession of such rare qualities in combination.

A modern author, in a work entitled "Horæ Subsecivæ," gives an amusing though forcible illustration on this very point. He describes a large dog who has seized a small one by the throat, and is holding him in spite of all endeavours to call him off. Some one proposes to bite his tail; upon which an individual steps out with great alacrity from the crowd, and, seizing the tail of the *wrong* dog, bites it with determination. For this act he gets knocked over, very properly, by the indignant owner of the small dog. Here, says the author, is an exhibition of *promptitude* without *power*.

I am afraid we might also class in this category the charge of the Light Brigade at Balaclava. Why is it that so frequently our cavalry, from their individual bravery and eagerness, have called down upon themselves just rebuke rather than praise? Is it not owing to the absence of power, or knowledge, which should curb rashness, and that inclination to prompt action which that arm has frequently exhibited?

In the Peninsular War it was made more than once the occasion of very strong orders on the part of the Duke of Wellington, who reprobated in no measured terms the headlong impetuosity of the cavalry.

An instance of this unfortunate tendency is also furnished in Sir William Napier's History of the Conquest of Scinde. At the Battle of Hyderabad the precipitate and entirely unauthorised movement of the cavalry posted in observation on the right might have compromised the safety of the entire army. I bring forward these examples, not from any wish to bring discredit on this most gallant arm of the service, but simply to show that judgment based upon professional knowledge can alone be productive of good results. We may also sometimes see *power* without *promptitude*, and in either case the loss of the wanting quality is sure to mar a man's usefulness in life.

Then, again, the educated officer is ready for the opportunity when it arrives and is prepared to turn it to account. The old saying that opportunity makes the man, is, I think, entirely wrong, at least as it is generally understood and employed. Far nearer the truth would it be to say that *man makes the opportunity*. In this lies the whole secret of success in life, and from my experience in the work of professional education, and pretty extensive dealing with young men on their first entering life, I can safely say that this rule holds good universally.

Evening Meeting.

Monday, February 3rd, 1862.

Captain E. G. FISHBOURNE, R.N., C.B., in the Chair.

NAMES of MEMBERS who joined the **INSTITUTION** between the 20th January and the 3rd February, 1862.

LIFE.

Staveley, C. W. D., C.B., Col. 44th Regt.

ANNUAL.

Frank, P. Staff Asst. Surg.
Molesworth, A. O. Lieut. Roy. Art.
Slesson, E. A. Lieut. Roy. Art.
Herbert, W. H. Captain 84th Regt. 1*l*.
Jackson, J. M. Com. R.N.
Ross, John, Lt.-Col., C.B., Rifle Brig. 1*l*.
Thesiger, Hon. C. W. Major 6th Inns. Drgs. 1*l*.
Swindley, J. E. Capt. 6th Inns. Drgs. 1*l*.
Billington, G. M. Capt. 6th Inns. Drgs. 1*l*.
Hardy, John, Capt. 6th Inns. Drgs. 1*l*.
Bennitt, W. W. Lieut. 6th Inns. Drgs. 1*l*.
Stevenson, Hew, Lieut. 6th Inns. Drgs.
Turnbull, G. A. Surg. 6th Inns. Drgs. 1*l*.
M'Master, V. M. Asst. Surg. 6th Inns. Drgs. V.C. 1*l*.
Hollist, E. O. Lieut. Roy. Art. 1*l*.
Smith, H. C. Lieut. Roy. Ind. Engs. 1*l*.
Mackenzie, R. Lieut. Roy. Art. 1*l*.
Nangle, W. C. Capt. Roy. Art. 1*l*.
Wood, H. G. Lt.-Col. 2 Batt. 8 King's.
Hennis, W. H. Ens. 2 Batt. 8 King's.
Shirreff, Rd. F. Lieut. 2 Batt. 8 King's.
Liddon, M. Ens. 2 Batt. 8 King's.
Dawson, John, Ens. 2 Batt. 8 King's.
Austin, E. F. Capt. Roy. Hosp. Chelsea.

AN ACCOUNT OF A LEAD-COVERED KARRACK OF THE MIDDLE AGES.

By Lieutenant A. T. Windus, H.M. Indian Navy, F.R.G.S., F.S.A.

In connection with the production of the paper I have the honour to read to you this evening, I feel it is necessary to explain that it was prepared in its original form exclusively for the Society of Antiquaries, being aware that, although the subject is a curious and interesting one in itself, as a link between the past and the present, and apropos of one of the great leading questions of the day—ships plated with metal, for defensive purposes—yet it is merely a communication that would interest any circle, though perhaps more peculiarly antiquaries. I here mean that there is

nothing practical to be derived from it, and, as we are accustomed in this Institution to endeavour to extract what honey we can from the papers that are read and questions discussed in this room, in the way of addition to our stock of information on the various scientific topics laid before us, I must deprecate the criticism to which I should naturally be exposed, if I volunteered the subject as one of real scientific and practical import; but this being conceded me (and I shall accept it with gratitude), I lay the matter before you with the greater confidence as a curious and interesting one, from which, by an after arrangement, since the first production of the paper, I trust we may make some practical deductions. Its more appropriate place, I believe, would have been as a sort of preliminary paper, spliced on to Captain Halsted's lectures of last year, and I did indeed offer to place it at his disposal, but he very kindly seemed to think it was worth working up into a special paper, which led to my laying it before the Council. Since then, in return for the consideration it received, and which has led to the reading this night, I have endeavoured to render it more worthy of your attention, by attempting to derive something of practical benefit from the shrewd scientific nautical ideas of the Knights of St. John, in 1530, by means of some experiments I have recently made on the resistance of lead to rifle balls, as compared with that of wrought-iron plates, which, with the permission of the Chair, I shall be happy to lay before you.

Before proceeding to read the paper I must also remark, that, as is often the case, I stumbled upon the subject by mere accident, while looking over a venerable volume, in company with my friend Sir G. Bowyer, who directed my attention, as one naturally interested in naval matters, to an account of the squadron fitted out by the Knights of St. John of Jerusalem, to operate, in conjunction with the forces of the Emperor Charles V., against Barbarossa, at the siege of Tunis. On going deeper into the matter, the account became so interesting, and some of the details approached so curiously to an engrossing theme of discussion and argument of the present day, that I really thought it worth introducing to the notice of the Society of Antiquaries, to which I belong, and the paper was drawn up, and read accordingly.

I therefore crave your indulgence to let the facts speak for themselves; the literal translation is rigidly adhered to—I have not attempted to strain points or ornament the details in any way.

After all, it is but drawing a parallel between two eras of ship-building, the very earliest and the very latest—I here mean war-ships carrying heavy artillery—in bringing the sixteenth and nineteenth centuries, the years 1535 and 1861, into a little closer contact, in point of nautical invention and contrivance, than one would suppose possible; in point of fact, I am about to introduce the crack ship of the Knights of St. John of Jerusalem—the "Santa Anna," of about 1,700 tons, built at Nice about 1530, to our Admiralty iron-sheathed crack ships of 1862, and to trace in the description some curious points of analogy—this is all I venture to proffer, and I trust these points will in some measure interest you.

The work from which I have made the extract, the translation of which I shall have the honour to read to you to-night, was written and published towards the end of the reign of our Queen Elizabeth, or about 1594. It is entitled, "Dell' Istoria della Sacra Religione ed Illustrissima Militia

di San Giovanni Gierosolimitano di Jacomo Bosio," and is dedicated to Monseigneur de Wignacourt, Grand Master of the Order.

The author, Jacomo Bosio (who, by the way, in the translation of this very work by Boyssât, published at Lyons in 1612, is miscalled Antonio Bosio), was a knight of the order, and it would seem quite devoted to its interests, as he appears to have entered *con amore* into the task he imposed upon himself of writing with great detail the history of the Sacred Order to which he belonged, the produce of his exertions being very voluminous, extending to three large volumes, containing much curious information upon the history and proceedings and the military and political influence of the Order of St. John up to the year 1591.

The detail in which he indulges will be clearly shown in his description of the Karrack, previously to entering upon which, however, I will, with your permission, and as briefly as possible, lay before you the circumstances that introduce her upon the scene.

It is the month of July, A.D. 1535. Muley Assem, the dethroned king of Tunis, has made an appeal to the Emperor Charles V. of Germany, imploring him to espouse his cause against the usurper Barbarossa. The Emperor, excited more probably by the *éclat* of the thing, and the prestige he would attain, if successful, in Europe, than for any particular sympathy with Muley Assem, has yielded to his entreaties, and with a splendidly-organised force set sail from the port of rendezvous, Cagliana, in Sardinia, on the 16th.

The fleet consisted of nearly 500 vessels, Flemish, Portuguese, Genoese, and a squadron fitted out by the Knights of St. John (always ready to engage the infidel), first and foremost among whose ships is our karrack, the "Santa Anna."

This formidable expedition was under the command in chief of the celebrated Andrew Doria, the most celebrated naval officer of the age, who was appointed High Admiral of the Fleet, and carried on board 30,000 regular troops, the flower of the regular armies of Christendom. The expedition arrived in the Bay of Tunis after a few days' prosperous voyage; the troops were landed without opposition, and the great fort of Goletta, which commands the Bay of Tunis, was immediately invested by land and sea. This fort of Goletta had been strongly fortified by Barbarossa at a vast expense, and he trusted chiefly to its strength and a body of Turkish soldiers, armed and disciplined after the European manner, for any chance of success against the veteran forces of the Emperor. To give an adequate idea of its strength, it may be stated that 300 cannon of large calibre, mostly of brass, were mounted on the ramparts—a prodigious number for that age, and a striking proof of the power of Barbarossa and the greatness of his preparations. It is the more necessary for my purpose to call attention to the armament of this fort, as will be seen hereafter, as for several days its formidable batteries played upon the invading force by land and sea. However, all these preparations were of no avail, the breaches soon became practicable; the fleet, with the great karrack holding a conspicuous position and gallantly playing her part, battered the fortifications with great fury and success; and on the 25th July, only nine days from the fleet leaving Sardinia, a general assault was given on all sides at once, and the place taken by storm.

I have compiled this account from histories of the period, more particularly Robertson's "Charles V.," which agree in all main points with our author, though he naturally enters more particularly into the special achievements of the knights of the order and of their squadron.

We therefore find this great Caracca della Religione, the "Santa Anna," laying off the port of Tunis, at the end of July, 1535, and most probably repairing damages in company with the rest of the fleet, after the bombardment. And I take up our author's account at the point where the recently restored King, Muley Assem, attracted by curiosity to see the galley which had exhibited such prowess, and from her size, fittings, and armaments, was the wonder of the day, proceeds on board to visit her; and the following translation describes her appearance.

Literal Translation.

"And he (Muley Assem) having seen the karrack of the Religione, "which caused him great wonder from her external appearance, became "desirous, above all things, of being conducted on board her, and to be "shown her internal arrangements, which was carried into effect, and he "was introduced on board by the bailiff (a Grand Cross of the Order) and "the Captain Touchbœuf, and received with all due honours and ceremonies and a salute of artillery, as became his rank.

"And having returned on shore, he reported to the Emperor the wonders "he had seen, and that he believed he had never before seen anything so "astonishing.

"And, so much he said that he caused the Emperor (who, it seems, had "never been on board) to desire to visit her himself, which he shortly "afterwards did before he left the army. As it has been already said (in "a former part of the book), she had been already visited as the wonder of "the age by the Court of France, so that it appears convenient in this "place to give some account of her marvels, for, independently even of the "stupendous size of her anchors, masts, stoutness of rigging, admirable "machinery, and other appurtenances of her fittings, this karrack was a "superb and mighty vessel of war, and would carry ammunition and provisions for a six months' cruise at sea, and was capable of carrying a much "greater freight than the karrack Grimalda, which, when near her, seemed "to be, so to speak, in point of size, her daughter, and yet she had taken "on board in Xiarca more than 40,000 salmi grosse of wheat of the "measure of Syracuse; and the other galleys, having often had occasion "to approach her, for the purpose of speaking her, the loftiest of their "spars barely approached within a foot of her great poop. She had six "decks (of which two were under water), all sheathed with lead and bolted "with brass, which does not consume lead as iron does, and, thus constructed, it was impossible to sink her, although all the artillery of a fleet "were fired against her. Her huge mainmast was made in pieces, and of "such size six men could not embrace it. She had three tops, one above "another, topmast above topmast, and constructed not merely for convenience of setting the sails, but also to mount small pieces of artillery, "which she always carried. Her timbers were so strong and thick, that "having been many times engaged, and received much cannonading, she "was never pierced below the bulwarks.

"Old men still relate as a wonder that at the time of her construction a "great pestilence and mortality occurred at Nice, and caused so great an "infection of the air that even birds that passed over frequently fell dead, "yet no one perished among all the men who were employed in the "karrack on account of the great fires made on the shore, to carry on the "works of iron, pitching, smelting, forging bolts, &c.

"She had a large and spacious chapel dedicated to her name, Santa "Anna, also an armoury fully equipped with every sort of arm, offensive "and defensive, for 500 men. Also a reception hall, with inner rooms or "cabins, for the use of the Grand Master and Lords of the Council, and a "refectory where the knights eat, fitted up with all necessary accommodation, "lockers for plate, and table furniture. All her officers, who were double "in number, had convenient berths. She had various lodges and galleries "round the poop, and chests and boxes full of earth, wherein were planted "cypresses and divers other trees and flowering shrubs after the fashion of a "garden, small but beautiful. No one on board was obliged to eat biscuit, "as there was a constant supply of fresh bread, for she had the convenience "of hand-mills and ovens, capable of turning out two salmi of bread at "each batch. There was also no lack of abundance of sweet water.

"She carried a blacksmith's forge, so convenient for all purposes, that "three master blacksmiths were generally employed night and day, and "wrought with the same facility as if they were on land.

"She was entirely sheathed with lead from the bulwarks downwards, and "below the water-line bolted with brass bolts, whereby she was rendered "so water-tight it was never necessary to pump the hold out, except on "account of water which might have entered from above.

"But all her wonders and novelties were surpassed by the number and size "of her columbines and heavy artillery, which were mounted on her upper "decks, poop, forecastle, and waist, to the number of 50 pieces, besides an "immense number of pieces of lesser ordnance, of every size and calibre; "and she was marvellously furnished with every convenience for the gunners "who worked them.

"Lastly, to crown the perfection of this admirable floating fortress, she "was very fleet and manageable under sail, and easily worked, and in point "of ornament was decorated with many beautiful paintings, and numerous "pendants and flags. She carried three great lanthorns and a band of "music of trumpets and clarions. Her crew alone consisted of 300 men, con- "stantly on board. She carried two great boats of 15 benches hoisted up "to her poop, and beside these five others, and with these she had many "times captured Turkish galleons."

There are several points about this curious description of considerable interest to a professional man, and to which I will briefly allude presently; but the main one is obviously that bearing upon the topic of the day, *i.e.* the metal plating with which the sides of this huge vessel were covered. I submit to you that this karrack, "Santa Anna," was the "Warrior" of the period. Built at Nice about 1530, at the expense of the Knights of St. John, all the mechanical skill of the age appears to have been lavished on her construction.

It certainly appears from the description I have just read, that the

method of completely sheathing her with lead over thick timbers, below the *opire morté* or bulwarks, is especially brought to notice, and commented on, as a novelty. It was, no doubt, quite a new experiment.

That this sheathing or plating was manifestly intended for defensive purposes, appears by its having been applied to the sides of the ship immediately below the said *opire morté*, or bulwarks, and over the whole of the surface of her four decks, between the lower part of the bulwarks and the water-line, and thence continued below the surface of the water, with this difference, that brass bolts were used below the water-line, to counteract the action of the water. This circumstance shows the great forethought and general attention paid to the construction of this galley, as I will presently show that 200 years later scarcely a ship of the British Navy was sheathed at all, and when so sheathed iron bolts were used for a considerable period. But to return to the upper plating. Our author expressly states, that so defended it "was impossible to sink her, although all the artillery of a fleet were fired against her;" also, that, having been many times engaged, and received much cannonading, she was never pierced below the bulwarks. It has been already shown that she must have been exposed to a very heavy fire from the formidable batteries of Goletta, and no doubt the battering she there received is included. All I wish to do is to make my case out, that a metal-sheathed vessel of war did exist at this early date; that she was impenetrable to the artillery of the period; and, consequently, she answered the purpose of her designers, as we only hope our future iron fleet will, constructed by Messrs. Scott Russell, Samuda, &c., whom I heard so eloquently advocating the great cause of iron *versus* wood the other day at the Society of Arts. With regard to the sheathing below the water-line, it is a fact that no ship of our Navy was ever sheathed at all before the year 1761, 230 years after the date I have been speaking of. I find in the various records of the Royal Navy, that copper sheathing was applied first by way of experiment to a 32-gun frigate, the "Alarm," in November of that year. There was great prejudice, as usual, against the innovation, and it was not till 1764, in the month of April, that the operation was repeated in the "Dolphin," of 24 guns. It was not till the Revolutionary War in 1783 that this important principle was carried out in all the ships of the service; but mark, during all this time iron bolts were used. Apropos of the brass bolting of the sheathing of our karrack (brass being, to all intents and purposes, the same as copper on non-corrosive grounds), I find the following extraordinarily apposite remarks in "James's Naval History":—"In November, 1783, after various vain attempts to counteract the effects of the copper sheathing upon the iron bolts, it was ordered that copper bolts should in future be used under the load-draft of water in all the ships of the Navy."

There are many remarkable features in the equipment of this extraordinary vessel of war, showing a great advance in the age, for it must be observed that before this period ships carried no porthole guns, or, indeed, more than one mast. What her tonnage was is impossible to say with any degree of accuracy. From the description of a painting of her that exists on the walls of the Palazzo of the Knights of Malta at Rome, I am inclined to think she must have closely resembled her contemporary of England, the "Henri Grace de Dieu," built at Erith in 1515, but

about 500 tons larger, and probably carrying two more decks. It is not quite clear to me how our author reckons his number of decks; and possibly the two half-decks of the poop and forecastle, corresponding to those in the accompanying picture of the "Henri Grace de Dieu," might be meant.

I find, by way of comparison, the crew of the "Henri Grace de Dieu" consisted of 350 soldiers, 300 marines, and 50 gunners—about 700 full complement; so our karrack, by the provision made in her armoury, must have carried 500 fighting men, besides her working crew of 300, and the knights of condition and their establishment—in all, no doubt, exceeding 1,000 men of all ranks.

Her armament consisted, it is certain, of 50 heavy guns of one calibre, the "innumerable" multitude of other pieces being swivels—murdering-pieces as they were then called—falcons, sakers, and divers other pieces of strange nomenclature.*

With regard to her mainmast and its enormous size, I have no hesitation in saying that it was probably one of the first built spars that was ever made; it is stated distinctly to have been made in pieces; indeed, a spar of such magnitude, if described correctly, could not be otherwise, as no tree could have supplied it. I have consulted various works on mast-making, and early shipwright works in the dockyards of England, but can get no decided information as to when built spars came into general use beyond the middle of the seventeenth century, when there is no doubt they were generally used. Of course the invention refers itself to a time when ships increased in magnitude, and proportionate spars were required; but,

* The Henri.—The drawing of the "Henri," exhibited this evening, is re-drawn from the Pepysian Collection, in Magdalene College library, Cambridge, and I have re-drawn her on rather a large scale, as I think she must be something of the build of the karrack. In Durich's "Memoirs of the Navy," he says, "In these days (sixteenth century), since the change of weapons of fight, King Henry VIII. making use of Italian shipwrights, and encouraging his own people to build strong ships of war, to carry great ordnance, by that means established a puissant Navy." Consequently it is highly probable that the "Henri Grace de Dieu" was built upon an Italian model, and, being more of a show ship than for work, had more incumbrances given her in the way of poop and forecastle. It is impossible that a thing like that could have knocked about the Mediterranean as this karrack is reported to have done; and the "Henri" certainly never put to sea, except, it is supposed, on one occasion. She may be the ship that took Henry VIII. over to France in May, 1520.

In other respects, and judging from the description I have read to you, we may suppose the arrangement of the decks to be much on the same model.

Her armament from the original MS. is very curious, and throws some light on the naval equipments of the period:—

"Gonnes of Brass.—Cannons, 4; demi ditto, 3; culveryns, 4; demi culveryns, 2; sakers, 4; cannon perers, 2; fawcons, 2.

"Gonnes of Iron.—Port pecys, 14; slyngs, 4; demi slyngs, 2; fowlers, 8; baessys, 60; toppe peces, 2; hayle shot peces, 40; hand gonnes complete, 100."

A cannon, or cannon royal, was a 60-pounder; a demi ditto, 32-pounder; cannon petronel, 24-pounder.

Charnock remarks, with reference to the number of these guns, that a great many of them were of a very small calibre, and indeed would be called nothing more than swivels in these days, carrying a pound or a pound and a half ball. The "Henri," which according to report might be supposed to have carried 122 pieces of cannon, had not more than 34, according to the modern acceptation of the term, that could be properly so called.—A.T.W.

The plate now given is from a painting by Holbein himself of the "Henri Grace de Dieu," and may therefore be considered as authentic; it differs in some respects from the sketch in the Pepysian Collection.—Ed.

in any case, I think I can claim for the karrack's architects the honour of being the originators, or certainly the first in the field.

The last point of interest about her which I will mention is a rather important one, for it touches upon provision for the inner man—the nautical stomach of the period. This redoubtable galley was so well provided with ovens, that she turned out daily enough fresh bread for all hands. What a blessing!—I speak feelingly myself, having been fed on biscuit for many a long day since the year 1844, so I envy these lucky sea-dogs of 1530 proportionately. I think Anson would scarcely have lost so many men in the old "Centurion," 200 years later, from scurvy and other diseases, if she had been fitted out somewhat after the fashion of this "Santa Anna;" for it is notorious, the wants and comforts of the seamen of our Navy were frightfully disregarded 100 years ago. I need only refer to Smollett's accounts of a man-of-war in George II.'s time.

A picture of the karrack exists, painted in panel, on the walls of a room in the palace of the order at Rome, and I regret that it has been impossible for me to procure an illustration of her; but, from all accounts I can gather of the painting, she resembles the "Henri Grace de Dieu."

There are many points about her construction and equipment which would be amusing to discuss in a naval coterie, but which I will not enter further into, as they do not bear upon the main point; but I really do think, by way of conclusion, that, taking all these facts I have laid before you into consideration—of course allowing for a little exaggeration of tone arising from the enthusiasm of the author, an enthusiast for the interests of his order, or anything touching the dignity thereof, but otherwise an honest and unimpeachable writer,—the subject is worthy of notice, merely from its associations. We all know in the course of miscellaneous reading how oddly we tumble upon passages that throw a light upon apparent unmeaning nomenclatures, a lustre upon some observance still kept up but forgotten in origin, that a thrill of interest is awakened almost involuntarily in our hearts as such light breaks in upon us; where could I, in the place where I stand, illustrate this more appropriately than by instancing a very matter-of-fact spot, only a few score yards off? We step from our cabs and omnibuses at Charing Cross, and proceed on our various routes of duty or pleasure. We never give much thought about the place or matter, except that our old historical reminiscences recall the funeral *cortège* of Queen Eleanor and the various crosses erected by good King Edward; but here the very name is significant in the last and most hallowed resting-place; and, in the mellow radiance of the light of archæology, prosaic old Charing disappears, and La Croix de la chère Reine stands forth in a halo of domestic affection, a memento for ever, while London endures, of the conjugal love which hallows the last resting-place of "the dear Queen." May we shortly hope to see another more substantial and enduring monument raised in our metropolis to the memory of one lately withdrawn from the same high station, where he shone as a star in our social firmament, who has passed from amongst us since this paper was written, and whose loss to this and all literary and scientific institutions was so eloquently deplored by our gallant Chairman at our first evening meeting.

Pardon the apparent digression while I make the application. Even so it is in this matter-of-fact age. I submit that it is worthy of notice—a

remarkable fact—that whilst in this year of grace (1861-2) all England is ringing with the great discussion, Iron *versus* Wood, as applied to vessels of war, and the merits of plated ships and invulnerable rams, &c., are warmly canvassed at every hearth, and in truth become very "household words,"—it is a remarkable fact, and one that brings home this very topic of the day to us as a nautical nation, always keenly alive to improvements in nautical science, or anything, indeed, touching upon naval matters, whether in their own or any other country, that 325 years ago, and contemporary with the first ship of the British Royal Navy, properly so called, that ever mounted a gun, a great vessel of war did exist, of which few of us, I may fairly suppose, ever heard, sheathed with metal, her sides impenetrable to the artillery of the day, brass-fastened, fitted with every convenience, carrying provisions for six months, baking her own fresh bread day by day for a crew of certainly 900 to 1,000 men and officers, also fitted with made spars and other improvements generally considered of much later introduction. I must, in conclusion, make these facts my apology for coming at all before you, and really I think they would seem to justify the old adage that "there is nothing new under the sun."

The only fact of real practical import to us in the curious description of this karrack, is that of her being cased with lead, and that this lead, overlaying thick timbers, resisted the fire of the artillery of the period; and this leads us naturally to ask ourselves, presuming all this to be true, and there seems no reason to doubt it, what are the properties of lead as a resisting medium, and why may it not be rendered available for the same purpose at the present day? It is only just that a subject of this kind should be ventilated, as it might posssibly prove of great importance; but, although much interested in the matter, it never occurred to me till very lately that I should myself be the means of introducing it publicly. Many scientific men, and men, too, who have had their attention particularly directed to this subject, have remarked to me, at different times, that they have had an idea of the application of lead to this purpose floating vaguely in their minds, but have dismissed it in consequence of the impracticability of obtaining experiments on a sufficiently large scale to effect any substantial proof. No experiments of any kind in lead have ever been made in England that I am aware of, but there were some in France, at Metz, in 1838. Captain Blakely has very kindly lent me a pamphlet containing an account of the practice carried on during that year against masonry, iron plates, &c., and the extract containing the experiments on lead I have translated, and will read to you presently, as it gives important information. Mr. Greener, of Rifle Hill Works, Birmingham, wrote me lately that he made some few trials of an iron ball against lead pigs, and that the iron ball was dispersed into innumerable fragments. He stated also that he suggested lead-casing for ships-of-war to the late Sir C. Napier, and that a correspondence took place on the subject, but it was concluded, without any experiments whatever, that the hamper would be too great on a ship's side in proportion to benefit derived. Having therefore no data to act upon, I determined to make a few experiments, as far as my limited means would admit, to determine what resistance lead would offer to rifle conical balls, which I think, from the peculiar nature of lead, is about the severest test to which

Lead Target 18 in.^s square. 3/4 in: thick

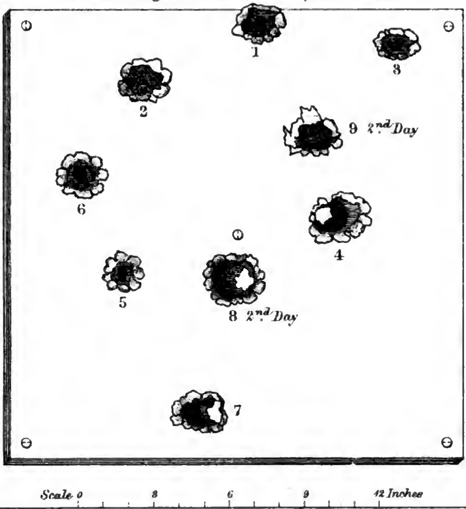


Fig. 1.

Fig. 2.

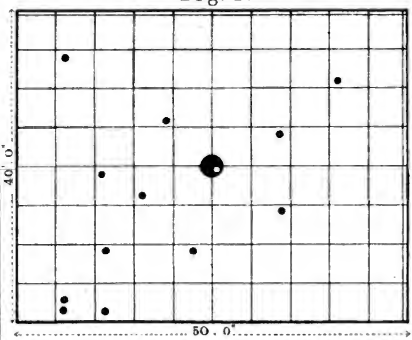
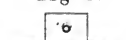


Diagram representing the practice on the 13th July 1858, by the late General Jacob, at 2,000 Yd.s with a Double Rifle made by George H. Daw. The Rifle was 32 Gauge; Wt. of Barrels 8 lbs; charge of Powder, 2½ drachms; Wt. of Bullet, 575 grains; wind from the right and rear of the Shooter.

14 Shots Fired .. 13 Hits _ One Bull's Eye.

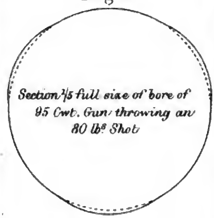
Fig. 3.



Actual apparent size of Target 50 ft. x 40 at 2,000 Yd.s

Bore of Gun Scale 1/5 of an Inch showing twist 1 in 30

Fig. 4.



Grooves 1/5 full size.

Fig. 5.

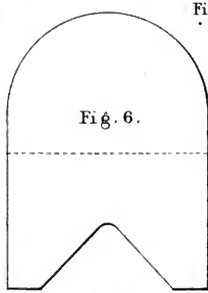


Fig. 6.

Section 1/5 full size 80 lb.s Compound Shot

it could be subjected. I have used a double Jacob rifle, 32 gauge, 24-in. barrels, made by Messrs. Daw, Threadneedle-street, one of the most perfect penetrative weapons that I know of. I am very glad to have an opportunity of speaking of this rifle, as its merits are above any eulogy of mine, and its effects are seen on the targets here by me (Plate A, fig. 1). The sister rifle to the one on the table by me, made on the last models of the late General Jacob, went out to Scinde early in the year of the mutiny, while this accompanied me to India a little later, and in a diagram I have here of some practice at 2,000 yards with it at Jacobabad shows its merits to be of no mean order (See Plate A, figs. 2, 3). I only allude to this to show that the experiments I made were conducted with efficient ordnance.

Now the question you will naturally ask is, What do I want to prove? —that lead is better than iron as a defensive resisting medium? Certainly not. I disclaim that at the very outset. But that lead might not be used in combination with iron, I do not feel quite so sure of. Supposing it possible to get over the grave objection of the enormous specific gravity of lead in proportion to wrought iron, which is as 1.48 to 1, and that three inches of lead on the sides of the "Warrior" are found to do the duty of the four-and-a-half-inch plating, and about equal the hamper on the sides,—should we derive any solid benefit by substituting lead for iron? The question of expense, of course, is important, but may be answered by the fact that lead always commands its price—like copper boilers for ship's engines, will always sell at market price when broken up. Also lead is a metal so easily worked that plates could be supplied at a rate not over 25*l.* a ton, including all expenses; whilst the wrought-iron plates of the "Warrior" are calculated to have cost the country at the rate of 50*l.* Again, repairs of damages could be very easily effected by a few ladlefuls of molten metal applied to shot-holes, and giving the ship a list for greater convenience. Lead is of that soft non-elastic nature, as we all know, that the whole force of a shot is brought to bear upon the immediate point of impact. There is no radiation of support, certainly, but then, from this very quality, no fracture can be occasioned in the rest of the plate—the damage is confined to the immediate point struck. I merely argue here the advantages that lead possesses, supposing it to be used; but as it is impossible to get over the fact of its enormous weight in proportion to its powers of resistance, or that 3¼ inches of pure lead, and, for the matter of that, 6 inches, will not do the work of 4½ of the best wrought iron, I will at once read you the report of the French experiments, and also of my own humble ones on the targets beside me.

EFFECTS OF COLLISION OF PROJECTILES WITH MASSES OF LEAD.

"A cast-iron projectile, which penetrates a mass of lead at the lesser velocities of 200 to 250 metres, does not break up, but causes a hollow of regular conformation in the mass. The metal, receding from the shock of impact of the ball, is forced up and outwards, and the mouth, so to speak, of the perforation formed in extending itself rips open, and presents the appearance of a serratic edging, similar to the acanthus leaves of a Corinthian column.

"With greater velocities the projectile is broken up, and the frequently numerous fragments cause a change in the regular appearance of the interior part of the hollow formed, but the exterior border still presents as bright and perfect an appearance, though more developed in effect. A shot fired at the velocity of about 380m. has given a consequent perforation of 0.280in. diameter, nearly double that of the projectile itself. A shot

of 24 calibre has been broken up into more than a hundred fragments, and the penetration has not been more than 0·16m.

"A shot of 8lb., fired at a velocity of 315m., which has been brought to the notice of the Congress, shivered into four principal fragments. The two targets of these showed fissures in addition, into which the lead, compressed by the impact of the shot, had introduced itself.

"The foremost surface face of the ball was forcibly flattened and widened out 0·009m. on a ring-shaped belt, the inner radius of which was about 0·335m., and the exterior radius about 0·065m. That part of the surface of the shot displayed concentric curvatures formed by the lead which had adhered there.

"SUMMING-UP.—Metal of the hardest nature, then, has been not only broken up by the concussion, but even its surface has been flattened down and depressed by another metal altogether the softest."

Although the summing-up of the results of the experiments is favourable to the resistance of lead as opposed to iron shot, yet we can gather nothing from them of any importance to justify the application of lead to the purpose we are discussing. The pith of the information we obtain is, that 0·16 metres (about 6in. English) broke up the spherical shot fired against it (what the whole mass of lead consisted of is not stated), but the experiments were evidently conducted to try the resistance of lead as a matter of comparison merely with masonry, &c., in masses, not to test at what point of minimum weight and thickness it would resist the shot opposed to it. It is evident the mass of lead was out of all proportion to the force of the shot; and we can gather nothing more from it than from the instance I have quoted of Mr. Greener's experiment, viz., that an iron musket ball broke up against a lead pig, which is a very solid mass of good 2½in. thick. But what we can infer is, that the fact of the lead being penetrated to 6in. by a spherical iron projectile solves the question of pure lead being inapplicable as a defensive medium; also that the cavities formed by the passage of the shot are in enormous proportion to the calibre of the shot itself.

Therefore all the experiments, with one or two exceptions, that I have thought it useful and interesting to make, have been with lead in conjunction with iron, altering the arrangements of each with respect to each other, for the better judgment of most effective application.

They are as follows:—

EXPERIMENTS.

First Day's Practice at Camden Park.

Against a target (see Plate A) of ¾in. pure lead over ¼in. wrought iron backing, the whole bolted securely to 1¼in. birchwood; size of target, 18in. square; weapon employed, Jacob's double rifle, 32-gauge, barrels 24in.; pitch, four-fifths in the whole length; charge of powder No. 6, 2½ drams.; projectiles employed, Jacob's lead conical, shell ditto, solid wrought-iron ditto, steel-pointed ditto; also an old pattern musket, "Brown Bess," was employed by way of comparison, with lead and iron ball.

Range, 30 yards. The shots are numbered on the diagram:—

1st.—Brown Bess, lead ball. Effect: A heavy bruising blow, the ball flattening up, and forming a coat to the bottom and sides of the nest-shaped concavity created by the impact of the ball.

N.B.—This effect seems to me to be much the same in proportion to that which was probably caused by the antique ordnance on the sides of the karrack.

2nd.—Lead, conical; Jacob.—The great penetration of this ball is obvious as compared with that of the musket ball, but the weak point of lead as a projectile is manifested by the appearance as here presented; the whole mass of the bullet is flattened back, and forms a cup, in the centre of which may be seen the hind part of the bullet, with the patch still adhering. The reverse side of the target in contact with the iron is starred with the force of the blow, but, as is seen, the lead has not been penetrated through to the iron.

3rd.—Solid iron, Jacob.—The effect of this shot is peculiar. The bullet has penetrated close to the iron, swooped off almost at right angles, turned back, and formed a nest for itself, so large that it easily shook out on moving the target. The ball is perfect, but the point is slighly curved.

4th.—Solid iron, Jacob, repeated, as I considered the deflection of the former (No. 3)

before penetrating to the iron backing, attributable to the point of the ball having turned slightly on concussion. This shot, it is seen, at once penetrates to the iron, dinges it in, recoils, and imbeds itself, broadside on, in the back part of the lead ; but the force of the concussion has shorn off the head of the ball diagonally, as neatly as if applied to a grindstone.

5th.—Shell, Jacob.—The shell appears to have penetrated to much about the same depth as the plain lead conical ball before exploding, and the cavity formed presents much the same appearance, except that the *débris* of the shell (copper) are imbedded in the lead at the bottom. The whole cavity is perhaps very slightly larger than the plain (No. 2).

6th.—Another Brown Bess leaden bullet.—Scarcely any difference in effect produced.

7th.—Steel-pointed Jacob.—Certainly the hardest hit, and cleanest cut through of the whole number fired. Most of the lead is ripped off the shoulder of the steel point, which has inflicted a severe indentation on the iron and turned back into the lead.

8th.—This large hole (No. 8) was the work of a wrought-iron musket ball, made on purpose for me, and fired from Brown Bess, with a charge of 3 drams, at only 20 yards' range, on the second day's practice. By inadvertence, and owing to the target having been unbolted for the purpose of shifting the component parts as required, the iron backing was omitted, and the ball consequently passed clean through the lead, and expended its force on the wall behind. It would, no doubt, from its great initial velocity, have made greater impression than any of the conical projectiles from the rifle, and so forms a good comparison with the proportionate effect in heavy ordnance of the solid-shot smooth-bore guns, fired with high charges, at short ranges.

9th.—This shot, marked 9, was fired on the second day at the $\frac{1}{4}$-inch iron target, backed by $\frac{3}{4}$-inch lead, being a wrought-iron conical Jacob ball, at only 20 yards' range. The effect was remarkable. The iron is cut through with great force, and the jagged points driven into the lead, where they are seen still sticking, as also the ball remaining imbedded, broadside on, about $\frac{3}{8}$-inch deep in the lead.

A shot succeeding this last was fired at the same arrangement of the target—$\frac{1}{4}$-inch iron, backed by $\frac{3}{4}$-in. lead ; a Brown Bess leaden bullet, charge 3 drams, range 20 yards. Effect : Ball flattened up, deep dinge, and slight fracture in iron plate.

This shot affords substantial proof that lead projectiles cannot have equal effect to iron, when employed against iron. Neither the Brown Bess—at short range, with heavy charge—nor the Jacob rifle, could make any impression beyond a dinge and slight fracture, when charged with a pure lead projectile.

Second Day's Practice.

There is no diagram of these targets, as the plates were shifted nearly every shot.

Shot 1st.—Target $\frac{1}{4}$-in. best wrought iron, bolted over $\frac{3}{8}$-in. lead, and wood backing $1\frac{1}{4}$ inch. Ball, lead conical, Jacob. Charge $2\frac{1}{2}$ drams. Range 20 yards. Effect : Ball flattened up, dinge, and very slight fracture. This shot renders the proof more complete of the inefficacy of lead projectiles against iron.

2nd.—Steel-pointed Jacob ; target, range, and charge the same. Effect : The iron plate cut right through, the lead bulged into the wood. The steel point was broken up, apparently from the dead resistance of the thin plate of lead backing up the iron.

3rd.—Target, charge and range the same. Shell-percussion, Jacob. Effect : A slight dinge only inflicted, all further effect being prevented by the explosion. An analogous effect in proportion to a heavy ordnance shell against $4\frac{1}{2}$-inch iron plates.

4th.—Target, iron plate, $\frac{1}{4}$-inch, backed with $1\frac{1}{4}$-inch birchwood ; no lead used. Projectile, steel-pointed Jacob. Charge and range the same as before. This shot is interesting as compared with No. 2, as it shows a decided advantage in the lead backing over wood. The jagged points of the iron are forced back, and driven into the wood, and the wood itself penetrated to $\frac{3}{4}$-inch, where the head of the ball is found—the lead stripped from the shoulder, and the steel head itself completely rounded off, as if with a file, in passing through the iron. In No. 2 shot the thin lead plating between the iron and wood broke up the ball, steel head and all, and prevented the throwing back of the jagged points of the iron.

5th.—Target $\frac{3}{8}$ lead over $\frac{1}{4}$-inch iron. Charge and range the same. Steel point, Jacob.—This shot unfortunately struck just below the fracture of No. 2, and spoilt, to

the eye, the comparison referred to in note on No. 4. It passed through all, and lodged with great force in a brick wall behind, at about two inches depth.

6th.—The same experiment repeated. Effect: A very heavy and clean-cutting hit, the ball passing through all, and lodging in the wall. Both these last shots seem to show that lead in too small proportion for effective resistance is better applied as a backer to iron than before it, where it receives the first impact of the shot, as instanced in No. 2, where the steel-pointed ball, the most formidable projectile in my arsenal, was broken up by the lead after passing through the iron.*

I will not detain you long with the summary of these little experiments. That the lead forms a very efficient deadener or buffer to the iron is indisputable, and my iron plate remains almost intact, except two dinges, after exhausting all my hardest-hitting projectiles. I must here again deplore the want of another iron musket ball (which, in comparison with great guns, I may call my 95 cwt. 68lb. smooth-bore, which I believe most naval men are agreed as to its being the most effective armament for close quarters ever turned out); and one more shot so loaded against the iron plate over lead would would have settled the point to a nicety of their comparative resistances. But, from close inspection of the effects of the firing, I think I may safely say that an additional ⅜ in. of iron would be fully equal to the ¾ in. of lead; and, if this deduction be correct, it is evident that lead for defensive purpose is useless against rifled ordnance, or indeed any ordnance of our times. That in the case of the karrack it was really of service I am fully convinced; but it was against projectiles fired from clumsy ordnance, having great windage, mealed powder, and stone and irregularly hammered iron shot. Then, again, in the junction of lead and iron there would be the antagonism of the two metals to be considered, which, combined with the moisture that must necessarily be experienced, would lead to the inevitable and speedy oxidysing of the iron.

Professor Miller, of the laboratory at King's College, who has made lead peculiarly his study, and with whom I have conversed on the subject, could suggest nothing better than a coating of tar on the iron when in

* Subsequent to these experiments, and the reading of the paper, the following three shots were fired from different rifles of well-known names, by way of comparison with the effects of the Jacob.

February 18.

The target the same as on first day, ¾-inch lead over ¼ inch iron. Range not more than 15 yards.

1. Whitworth.—Charge 82½ grains=3 drams; ball, mixed tin and lead. Effect: Flattened up into a cup on arrival at the iron. No effect on the iron whatever. The cut through the lead very clean.

2. The Henry rifle.—Charge 91 grains. Ball, pure lead. Effect: A clean-cut hole, and dinge on the iron, the ball flattened, and recoiled back completely out of the hole immediately on coming in contact with the iron, leaving not a particle of its substance behind.

3. Westley Richards' breech-loader.—Charge 75 grains. Ball, mixed metal. Effect: Ball broke up and formed cup at the bottom. No effect on the iron.

Remarks.—None of these shots appear to have made greater impression than the Jacob pure lead, and certainly nothing equal to the Jacob steel point. The effect of the Henry was something more than the others, but the charge of powder was very large in comparison, being 91 to 68½ grains, the charge used for the Jacob in all the experiments.—A. T. W.

contact with lead. Felt, which I suggested, would absorb moisture, and so be consequently unfit; and gutta percha, without infallibility, would be an expensive experiment. It is a curious fact, that lead rather preserves the iron, if you exclude the atmosphere or any moist influence, as may be observed in the sinking an iron railing into masonry, and soldering with lead; the iron corrodes at the point of contact with the lead at the surface, but below, where air-tight, it is preserved. There is also another great defect in lead, which the experiments bring to our notice; viz., the huge cavities formed, in proportion to the size of the projectiles employed. It seems to be attributable to the following cause,—that the shot passes through, as it were, water, or as a ploughshare cuts through the ground; none of the lead appears to be driven before the ball, as far as I can discern from the effects on the wood backing, but the action is lateral, and the lead is thrown away and back on all hands, leaving a gap of such magnitude that a second shot would strike upon a perfectly defenceless surface of the wood or iron intended to be protected.

Lastly, supposing lead to be all we could wish in other respects, a great bone of contention would arise as to the method of bolting and securing it. I should suggest as a mere matter of opinion that no bolting could answer; that, lead being so soft, the working of a ship would soon cause a play round the bolts, and all become loosened. Besides, of what material are we to compose the bolts themselves, with the very perfect arrangements provided for chemical action, in the presence of lead, iron, and water in the bolt-holes? The only feasible method that occurs to me in such a case would be to form the outer surfaces of the iron to be protected into a series of moulds, into which the lead might be run.

However, we may fairly come to the conclusion that no man's ingenuity will ever be taxed for this purpose, as long as we have good Low Moor wrought iron. If anything is to be done at all with lead, and if timber is still to be continued in the construction of our plated ships, I should suggest that a thin plating might be used with great advantage between the iron plates and the timber to which they are bolted; it would tend to tighten up all more effectually; and we know that complaints already exist of the water making its way through the interstices of the plates, and lodging between them and the timbers; and, in addition to this, I have shown the good effect of the *vis inertiæ* of a thin plate of lead, in counteracting the effects of a heavy blow and fracture of the iron, and prevention of damage to the timber from splinters of iron being driven in.

In conclusion, I do not in any way regret that I have made these few experiments on lead as a resisting medium, and apropos of the curious narrative of the karrack; and, if any interest has been excited in the minds of my audience to-night, I shall feel amply repaid for any trouble I have taken to elucidate the matter.

Captain Grant: My object is to derive some practical value from the information which you have been kind enough to afford us. With reference to what you have said about supplying the inner man with baked bread—what sailors call "soft bread"—have you any means of giving us details of the mode by which that was carried out? If you have, it would be of great value to us.

Lieutenant Windus: I have searched very carefully for any details; in fact, the secretary, Captain Burgess, particularly asked me on the point whether there were any details concerning these ovens. But there is nothing more said beyond mentioning the bare fact that there were ovens on board to bake bread for the supply of the crew. This crew was very large undoubtedly.

Captain Grant: It would be of great advantage to be furnished with information upon that point. The Chairman will bear me out in that.

The Chairman: It would be very important. Were the dimensions of the karrack given?

Lieutenant Windus: No; there were no dimensions given beyond those which I have stated; you have it in general terms. Neither her tonnage is given nor anything else, except the remark that her mainmast was of such a size that six men could not span it. The thickness of the lead is not mentioned, only that she was covered with lead below the bulwarks. The calibre of the guns is not absolutely mentioned, but they may be supposed to have been 24 or 32 pounders—*i.e.*, the 50 porthole guns, called cannon. (See description of armament of "Henri Grace de Dieu.")

The Chairman: Nor of those in the Goletta Fort?

Lieutenant Windus: No; it merely states the fact that there were 300 brass guns.

The Chairman: It occurs to me that Captain Grant's ingenuity will make up for the deficient information with respect to the baking. I think with the quantity of fuel that is expended on board ship we might have a much better application of it. There is a great deal of fire goes up the chimney, and in all directions.

Captain Grant: I maintain we have heat enough to bake all the bread that is wanted.

The Chairman: And to ventilate the ship as well.

Captain Grant: Certainly; there is no question about it.

The Chairman: I am sure we are very much obliged to Lieut. Windus for his interesting paper. The information with respect to the karrack only shows the full value of an Institution of this kind for collecting facts. There is no doubt that, but for the ignorance displayed in our shipbuilding in former days, the value of copper and brass would not have been so long overlooked or have been so lately brought into use, if these facts had been known. The value of this Institution is in collecting facts of every description, so that inventors should not have to begin *de novo*, but should first come here to see what has been done. It is like a man going to read a paper upon any subject: he goes to all the authorities to see what has been written previously upon that subject. So in the case of our Institution, the inventor should be able to come here and ascertain what has been previously invented upon his subject. Therefore, all papers of the present kind are not simply interesting, but also useful.

In the reports of the experiments in France, there is information connected with these experiments which it would be desirable to give, viz. the velocity of the ball. It would throw considerable light upon the subject. There is no doubt it is the great velocity of the ball in Brown Bess which makes it so effective. It would, therefore, be desirable to ascertain in all these experiments the velocity of the ball in striking. It

would explain a great deal, and get rid of a great deal of unsatisfactory conflict of opinion about matters. The experiments I allude to are the more valuable, because, on a former occasion, Mr. Greener made some statements which seemed to be very apocryphal. Now, it seems from these experiments that that gentleman must have been under some misapprehension as to the facts. It is very difficult to get at facts; and his statements do not seem to have been founded on facts. Therefore, Lieutenant Windus has rendered a service in getting rid of these crudities, and I am sure you will all join me in thanking him very kindly for his interesting paper.

Evening Meeting.

Monday, February 17th, 1862.

Captain E. G. FISHBOURNE, R.N., C.B., in the Chair.

NAMES of MEMBERS who have joined the INSTITUTION from the 3rd to the 17th of February.

ANNUAL SUBSCRIBERS.

Adams, F. Lieut. Bom. Staff Corps. 1*l.*
Lewis, G. E., Lieut. H.M. Ind. Navy. 1*l.*
Mackinnon, L. B. Com. Roy. Navy. 1*l.*
Piercy, H. J. Major, late Bengal Army. 1*l.*
Fisher, H. C., Capt. West Essex Mil.
Gosselin, N., Lieut. 23rd R. W. Fus. 1*l.*
Blanford, Thomas, Ens. London Rifle Brigade. 1*l.*
Lucas, W., Dep. Insp.-Gen. of Hosps., Roy. Mil. Asylum, Chelsea. 1*l.*
Clayton, F. S., Lieut. Royal Navy. 1*l.*
Scott, Thos. A., Lieut. 28th Bengal N.I.
Warde, C. A. M., Lieut. Bengal Artillery.
Philips, Geo., Lieut. 2nd Queen's. 1*l.*
Russell, Lindsay, Capt. Roy. Engineers. 1*l*
Brady, Antonio, Esq., Admiralty. 1*l.*

THE PRINCIPLES OF RIFLED CANNON AND PROJECTILES.

By James Lawrence, Esq.

It is the object of this paper to endeavour to define those peculiarities in the construction of rifled cannon and projectiles which have a claim to be considered as the principles on which they are constructed, and to show in what respects they differ from an ordinary gun and round shot.

In order to do this, I think it will be convenient, not, indeed, for the sake of information, but for the purpose of starting on firm ground, where the foothold is safe, to shortly advert to those principles which are common to both descriptions of ordnance.

An ordinary gun, equally with a rifled gun, depends for its power of propelling its projectile on the complete ignition of the charge, and its consequent conversion into a highly elastic gas.

It is not disputed that in an ordinary gun the shot should be well rammed home; and the object of this ramming is, that the powder should

be compressed into the smallest space, and the shot brought as closely as possible into contact with it, so that on the explosion taking place the violence of the expansion shall be at its minimum when first brought to bear on the shot. It is obvious that, if this is the case, the instant the shot begins to move, the explosive gas becomes increased in bulk, and, as the first impulse has to overcome the inertia of the shot, it is then that the greatest strain is thrown upon the gun. Now this is one of the principles which is common to both rifled and ordinary guns, and the initial velocities of their projectiles depends upon the proportionate ratio of the volumes of the elastic fluid to the weight of the shot. The next point in which these two kinds of projectiles agree, is their action on the air in passing through it from the mouth of the gun till they arrive at a state of rest. Without entering into any discussion as to the amount of resistance offered to different forms of projectiles propelled at the same or different rates of speed, it is enough for the purpose to say that the air always offers the same amount of resistance to a round shot propelled at a given rate, and always brings it to a state of rest in equal times.

The air acts on an elongated rifle projectile in a precisely similar manner, for it is clear that, supposing the elongated projectile is from its form better adapted for cleaving the air than a round shot, this advantage applies to the whole of the range.

It is, therefore, impossible that a rifled shot can begin slower, and then go on faster, as some ignorantly suppose, or even much further than a round shot. It has no reserve of power; cannot obtain what may be called second wind—in fact it must, and does, follow the ordinary laws of nature, and move slower and more slow every instant after leaving the mouth of the cannon. This principle, however, it has been attempted to deny in the case of rifle projectiles, and it was boldly asserted, at the Institution of Civil Engineers, that different laws regulated the flight of round shot and rifle projectiles. I venture to advocate the simplicity of Nature's laws, and to assert that they are fixed, immutable, and not under the control of man. We now come to the points of divergence, the most important of which is, that the shot being elongated, and not spherical, is made to revolve round its major axis.

The object of this rotation, as is well known, is to correct the irregularity of the density of bodies of metal.

Some one part of every shot is denser than other portions, and this heavy part always exhibits a disposition to get to the front, dragging the rest of the shot after it in the direction of its own position. A rapid revolution of the projectile, of course, corrects this by constantly changing the position of its heaviest part, and thereby counteracting its tendency to act on the other portions of the same body. This revolution of projectile which we desire to produce in rifling a gun, may be fitly termed a fundamental principle of rifled cannon projectiles.

By its means we get accuracy, or rather the power of obtaining accuracy; for accuracy really depends on the skill of the artillerist as much as, or perhaps more than, ever. We have not yet, at least, got—and, probably, never shall get—an automatic gun that will load and point itself.

There are many ways of producing this revolution; such as the numerous small grooves of the Armstrong gun, the ovals of the Lancaster

and Whitworth, and lastly, but by no means the least effective mode, wide and shallow grooves. (See Plate A, figs. 4 and 5, opposite page 109.)

The last I believe to be the best—most certainly the best if cast iron is used; but, whether small or large, oval or hexagonal, none of them contain any principle; they are simply matters of convenience, and are only worthy of consideration as to their relative advantage in giving rotation to the shot with the least reduction in the strength of the gun. The revolution of the shot is attained by making an elongated projectile revolve on its greater axis, and is effected by friction against grooves formed in the bore of the gun; and this is another point in which it differs from a round shot fired from a smooth-bored gun.

A perfect rifled projectile is, for a reason which I will presently advert to, also necessarily expansive—that is to say, when it is fired it fills up the groove of the gun, and completely annihilates the windage.

The windage in a smooth-bored gun not only detracts from the accuracy of the shot, but subtracts from the strength of the powder, by allowing an escape of gas, and even of un-ignited powder, which an expansive, and, as I contend, perfect, projectile prevents. I repeat perfect, because such a projectile absorbs every portion of the force which is used to put it in motion. This friction against the sides of the gun is, therefore, an entirely new element in artillery practice; it is also an element of danger, tending to strain the gun; but, as it is also a necessary evil, the greatest care and intelligence should be brought to bear on the means of reducing this dangerous element to its lowest point. In every machine used for commercial purposes this is a primary object, and the whole art of a mechanical engineer may be said to consist in combating friction; for, after the principle of a machine is once settled, the reduction of friction by accuracy of workmanship, and the simplification of the parts, is the sole aim of an intelligent mechanic. In a rifled gun this object is effected, I believe in the best manner, by reducing the twist of the rifling; but, as this is a moot point, I will pass to one on which there is now no difference of opinion, although I at one time stood alone in advocating it,—I mean the necessity of greasing rifle projectiles for artillery. I saw the necessity of this at the first experiment I made in 1852, and in a letter to the late Lord Hardinge, which I apprehend is still to be found at the War Office, I pointed it out. This idea was totally opposed to all antecedent practice, and I had to bear the whole weight of the obloquy that is sure to attach to any putter-forth of strange doctrines. "Grease a cannon shot!" said the late Lord Raglan, "who ever heard of such a thing?"

Even so late as December, 1859, the same prejudice existed, and I had the mortification to witness the bursting of a 68-pounder gun of 95 cwt.—the only accident that ever occurred in my presence—because the artillery officer chose to consider that soft soap was a fair equivalent for Russian tallow, and would not believe that the lubrication of the projectile could have any effect on the life of the gun.

The principles just stated, although few and simple, will, if established, form a sound basis for the proper construction of cannon, and enable us to criticize, with assurance of accuracy, the pretensions of any novelty in the make of guns.

They define the relative position of the artillery officer and the mechanical engineer, and show that, so far from accurately-made guns supplementing the skill of the soldier, they task his abilities in a greater degree than ever, for a good rifled gun improperly directed or elevated is perfectly certain to miss the mark aimed at, and is not subject to the chances of a smooth-bored gun.

The ranges form an admirable test for the relative efficiency of rifled cannon, for it will require but this knowledge to decide the point with unerring certainty. Again, the motive power of projectiles being reduced to the simple element of the explosive power of gunpowder, no expectation of wonderful or extraordinary effects can be rationally entertained until some agent stronger than gunpowder is produced.

A larger gun may produce greater effect than a small one, but it will bear a strict relation to the weight of the powder and shot used. As well might we hope to get wonderful and hitherto unheard-of results from the power of steam, as from that of gunpowder. We have, in the one case as in the other, got perhaps near the end of our tether; and there ought to be no reason why a particle of doubt should hang over the results of rifled artillery practice, any more than on the duty to be obtained from steam. If it is otherwise, it is because every means has been taken to mystify and confuse the one subject, while in the other every vestige of quackery has been carefully expelled, and the facts have been rigorously sifted and investigated by men combining intelligence with honesty, and having no motive to deceive.

A few words, perhaps, may be allowed on the supposed advantages of very large guns, and to judge of this it should always be borne in mind, that, although we can make guns of any size we like, the men that are to use them can neither be made taller nor stronger, and that therefore machinery for loading any guns much over the size of those in present use must be employed, and this ought to be conclusive against their uses, as far as siege artillery and broadside guns are concerned.

The principles on which rifled projectiles are constructed may be reduced to two. The first, which must be considered rather rudimentary than perfect, is the projectile which is formed entirely of iron, and which is made to rotate either by projections on its sides, fitting into grooves in the gun, or by giving to flat surfaces a twist or pitch, answering to the internal arrangem et of the gun.

This form is in great favour with many persons who imagine that the liabilities of a gun to burst are greatly lessened by the shot being inexpansive and that the shot itself is more efficient from its being homogeneous, and not a compound projectile. There are, however, disadvantages: for unless the shot is made very carefully, and consequently very expensively, so as to reduce the windage to the lowest point consistent with its passage through the gun, the efficiency of the shot is reduced to that of the round shot it is intended to supersede. The result of making it fit tight is, that you have a shot much more liable to burst the gun it is fired from than a compound shot, because, if by any chance it sticks, the rigid character of the shot renders compromise impossible, and something must go. Even on the most favourable supposition that the shots always

fit as tight as possible, and never stick fast under any circumstances, the effects and ranges of such shots must always be variable, and in actual warfare exceedingly so, on account of the expansion of the gun by frequent firing, which, with a rigid inexpansive shot, must increase with every round.

The second principle is that of coating iron, more or less, with lead or zinc, forming a compound projectile. The objections just adverted to, are here evidently obviated, because the zinc or lead, being soft and expansive metals, have the necessary capabilities not only for filling the grooves of a gun at the commencement of firing, but also of allowing a margin for the expansion occasioned by rapid discharges during action.

They have a further advantage. The powder is more perfectly ignited when the shot is expansive, and it is found in practice, that, even with increased range and efficiency, a reduction of the charge, as compared with the charge for iron shot, can be made, amounting to between one-fourth and one-eighth.

These are the two principles which regulate the construction of rifled projectiles for artillery, but there is a modification of the last to which I must invite attention. It is the using two soft metals, as compounds instead of iron and lead. (Plate A, fig. 6.)

The effect of this is, that while with iron alone, or in combination with lead, you have a winged projectile, with the compound of soft metals you possess a missile which has properties not fully developed until the shot strikes.

This peculiarity is so entirely opposed to the prejudices of nearly every person, whether military or civil, that it is not wonderful it should have been so long overlooked. A shot compounded of zinc and lead strikes a harder blow than iron, and, curiously enough, it is against iron that this superiority is most remarkably manifested.

The reasons for this are twofold—the first arising from the fact that the harder of the two metals can be placed in front of the softer, so that at the moment of impact the softer metal behind yields, and the somewhat harder metal in front strikes against the far harder iron plate, and has little tendency to crush up; and the second, because, these metals being inelastic, they do not rebound like iron against iron. Iron against iron will make a hole, but the soft metal projectiles alluded to, not only make a hole, but effect an entrance; and the stoutest iron yet placed as a protection on vessels of war will not resist a shot of 60lbs. to 80lbs. weight, made on this principle, and fired from a 68-pounder.

These shots have been sent in very large quantities to America, and I believe elsewhere; but, although the inventor of them, I have never yet been able to get them fairly tried in my presence at home; notwithstanding, from circumstances with which I have been made acquainted, I have reason to believe that they have been made at Woolwich, and have still better reason to know that whole shiploads have been sent to America.

For myself, personally, I have had nothing to do with the manufacture of more than one shipment of some 1,500 9-pounder projectiles.

I will now conclude these observations by describing the trial of a new kind of shell—one of which is on the table—which is intended to penetrate iron, and was tried in October last at Shoeburyness.

Although the trial was so recent, the idea was hatched in 1856, when, after completing some experiments with solid shot, which to this day have not been surpassed, I made an unsuccessful application to the War Department to have a few shells tried.

Having, however, had the pleasure of hearing the papers on Iron-cased Ships read by Capt. Halsted in this Institution, in which he stated that ⅜-in. iron would keep out any shell in the service, I resolved to try again. In this resolve I was not solely actuated by self-conceit, but from memory of an experiment which I witnessed some years previously at Woolwich, when my soft shots were pitted against granite, and, as they made a great impression—1½ in. deep—in the stone, I argued that they would be equally effective against iron.

I was likewise aware that there was a general impression in the Navy that shells were more dangerous than solid shot, and on one occasion a gallant officer expressed this opinion by saying, "For God's sake, keep out the shells."

I accordingly wrote to the present Secretary of the Admiralty, who was acquainted with the commencement of my experiments in 1852, as well as personally acquainted with my late friend and patron Mr. Muntz, the Member for Birmingham, offering to make an 8-inch shell that should perforate 3-inch iron plates. Lord Clarence Paget referred me to the Secretary of State for War, who, acquiescing, referred me to the Select Committee at Woolwich. The Committee were willing to try the shells, but I wanted to test the matter on a small scale first, and I had some small shells made three inches in diameter. Unfortunately the Committee had no gun that would fire 3-inch shells, but stated that if I made some 4-inch they would not object to try them. This I did at some trouble and expense, but with a clear written understanding that the trial was to be a preliminary one, and that the shells should penetrate 1-inch iron.

When the shells were made and sent to Woolwich, the Select Committee handed me over to the Special Committee on Iron Plates. This body, however, reported to the Admiralty, they having no control over guns, being in this respect like the Admiralty; and they had no money to make experiments, the 15,000*l.* voted for that purpose having been taken from them when they were transferred to the Admiralty.

The gun at length furnished to me was an old iron one, cast some time in the reign of George III., and rifled on a principle which no person has ever since then advocated.

It was considered unsafe by the officers, and was fired with a long lanyard, and every one present was obliged to get under cover at each discharge, an arrangement that precluded careful observation. Bad as the gun was, however, it did not burst, and the shells went through the 1-inch plates with the greatest facility.

It appeared, however, that these soft-metal concussion-shells were expected to go through iron plates whole.

What they really did, however, was not very much short of this: that they went up to the iron *whole* was admitted, and as the time occupied in passing through the iron was but the 24,000th part of a second, and they carried their fire and fragments in with them, the difference was not much: but it was determined that the experiments should not be renewed.

The following week witnessed those experiments with the 100-pounder Armstrong guns, which proved that, in penetrating effect, they were inferior to the service smooth-bore artillery.

I suppose this abstinence from penetrating was ascribed to the good taste of the guns; it certainly has resulted in giving them a higher reputation, and in bringing them more extensively into use.

As to myself, I have spent nine years on these experiments—endured much labour—and spent some money. I had borne disappointment, and the sickness of hope deferred, with fortitude, though it at last has brought on a nervous affection of the heart, from which I have recovered so slightly that my appearance here this evening is not without risk, and nothing but a sense of the duty of fulfilling a voluntary engagement has induced me to be here.*

Extract from Official Reports of Experiments, showing Times of Flight of Rifled Projectiles, Form and Hoist of Grooves, as well as Depth, suggested by Mr. Lawrence.

Weight of shot, 80lbs.; charge, 12lbs.; weight of gun, 95 cwt.; length, 10 feet; twist, 1 in 30; grooves, 3; depth of grooves, $\frac{1}{10}$th of an inch; equal lands and spaces.

5″	elevation	2,595	yards	7″ =	1,112 feet per second.
10″	,,	4,100	,,	13″ =	946 ,,
27″	,,	7,300	,,	30″ =	730 ,,

Mr. Lawrence is desirous of adding to his remarks that he has actually witnessed a direct trial of the relative time occupied by the travelling of round shot and rifled projectiles of the same weight and propelled by the same charge. In that experiment the rifled shot went from 30 to 50 per cent. further than the round shot in equal times.

Commander Robert A. E. Scott, R.N.: I may be permitted to say, with respect to the velocity and range of projectiles, that if an elongated shot be fired at 10 degrees of elevation, with an initial velocity of 1,300 feet a second, and a round shot of similar diameter be fired at the same elevation, with an initial velocity of 1,600 feet, the range of the elongated shot will be considerably above 3,000 yards, and the range of the round ball will be under 3,000. This, I think, shows that Mr. Lawrence has made a mistake in saying that the velocity with which a shot leaves the gun determines the range. Also if a heavy elongated shot leaves the gun with a low velocity it will very possibly have a longer extreme range—that is, when you give the highest elevation, it will range further than a lighter elongated shot of similar diameter, which may leave the gun at a much higher velocity. With respect to what Mr. Lawrence says as to the expansion of shot, it must be remembered, that, in expanding out projectiles to take the rifle grooves, you very suddenly throw a great strain upon the gun, and call into play a very large amount of friction during the shot's passage through the bore, and in thus stopping the windage you really close the safety-valve of the gun. The next point which Mr. Lawrence has noticed is, the expansion of the gun from getting warm. The gun certainly does expand, but it is only in a trifling degree. But, granting that it did expand to a greater degree, what would be the effect? That, when your gun got hot, and the combustion of the powder became more perfect, the lead would be driven out more violently against the bore, which would

* The author has since died.—Ed.

more suddenly cut off the windage and throw a far greater strain on the gun. An iron shot, on the contrary, does not expand by the explosion, and hence gets more windage as the bore warms, so that its safety-valve gets larger as the gun expands and becomes weaker. With regard to simple cast-iron projectiles, there is a specimen placed on the table which can be cast at the same rate per ton as the round iron shell, and the subsequent planing of its bearings and zincing cost about three-halfpence per shot. But rifling is principally valuable on account of its giving the means of throwing a shell of large capacity. It has now been tolerably well ascertained that the simplest and best way to break iron plates, without straining the gun, is to fire round shot. All foreign nations are now striving to combine with the advantage of rifling—so as to use the elongated shell—that of still firing the round ball. Elongated shell are however only valuable if they have a great powder capacity; but if you took two metals—zinc and lead—and joined them in the way proposed, you would really have little or no powder capacity. Besides this, such a shell would be enormously heavy if made of the same diameter and of equal strength with this cast-iron shell for a rifled 32-pounder, which contains 5lbs of powder and weighs only 38lbs., or 6lbs. more than the round ball for the same gun. It is a common error to suppose, that, because a projectile is lead-coated, the strain upon the gun must be less, on account of the softness of the metal, than if the projectile were of iron only. Take the Armstrong shot: this, before the lead (hardened by tin) mixture is put on, is nearly the size that an iron rifle shot would be for a similar bore; and, when the lead is run on, it is larger than the bore. Hence, when the charge is ignited, an immense force is expended in compressing the lead, and squeezing it almost instantly into so many grooves; and consequently the strain upon the gun is enormous. Windage, on the other hand, if only a moderate amount be given, is an advantage, not only as a safety valve, but as a means of cleaning the bore of the gun; it also further reduces the strain by driving out the column of air which would otherwise impede the motion of the shot. When Mr. Whitworth fired a tight-fitting projectile, he did not get so great a range as that which he obtained afterwards on sloping away the bearings, and giving the projectile more windage; but what would be the effect of closing the windage by an expanding shot, if you placed a wad in front, in case of being at sea? The want of a small jet of gas to blow out this wad would very dangerously raise the pressure upon the gun; but with an iron projectile, where the windage is not closed, no such danger could occur from the placing of any wad to keep the charge "home." A wad would always be necessary if the vessel were rolling, and a vessel nearly always rolls if her engines be stopped.

Mr. Lawrence: Does Captain Scott mean to say that, with a difference of range so great between the elongated shot and the round shot, the diameter of the two shots is precisely similar, or that merely the weight is the same?

Commander Scott: The diameter of the elongated shot was rather greater, so that it was really at disadvantage in this respect.

Captain Blakely: It has been pretty well proved by numerous experiments that a 68-pounder, a 56-pounder, a 32-pounder, or any of the round shot, will leave the gun at a velocity of 1,600 or 1,700 feet per second; and at five degrees of elevation, if they range 2,000 yards it is considered very good. Whereas the long shot, whose velocity has also been measured, and supposed to have been correctly measured, and does not move more than 1,100 or 1,200 feet per second, really ranges more. Those actual measurements, I think, must have great weight in coming to any conclusion. I should much like to know, if Mr. Lawrence would be kind enough to inform the Meeting, what was the exact nature of the shell?—how the soft metal was made into the shell? Did it hold powder, or was it intended to burst into fragments?

Mr. Lawrence: As I said before, the shell which I supplied was intended for a preliminary experiment, and therefore the capacity of the shell was by no means tested. I designedly did not make the shell so capacious as I believe it could be made. The only difference I make in the shell and the solid shot is that I have necessarily put cast-iron in the centre of the shell, for the purpose of preventing the charge blowing up the shell in the gun. That is the only difference. There is nothing but a mechanical junction between the iron and the lead or soft metal.

The Chairman: It is a cast-iron chamber?

Mr. Lawrence: Merely a cast-iron chamber. There is no galvanising or tinning.

The Chairman: And what sized chamber? What quantity of powder do you propose to put into the 68-pounder?

Mr. Lawrence: That is a matter of experiment. The contents of this shell on the

table is, I am told, about five ounces. But that is by no means fixed. I should make the shells as big as I possibly could, to hold as much powder as they possibly could; but, unless I have the means of making the experiment, I could not ascertain this point. As to Captain Blakely's other observation about the range, I can only say that I have seen an 80-pounder shot go 7,300 yards in twenty seconds. Now, I think the initial velocity of that shot must be more than 1,100 feet per second.

Captain BLAKELY: I am afraid a soft metal shell would only break into three or four large fragments.

Mr. LAWRENCE: It broke into hundreds of pieces.

Captain BLAKELY: Has it been tried?

Mr. LAWRENCE: It has. It went through an iron plating of an inch, and it broke into hundreds of pieces. There was a wooden screen at the back, and that was completely covered with fragments, and the piece of iron which was driven out was also driven into the screen at the back, and was quite warm. This shell was not more than four inches at the base, and at the top it is not more than two inches, but yet it took out a piece of iron from six to eight inches in diameter.

The CHAIRMAN: What is the relative expense of the description of shell which you advocate?

Mr. LAWRENCE: That cannot be decided unless made in great quantities.

The CHAIRMAN: What is the expense of the solid shot as compared with the rifled shot?

Mr. LAWRENCE: They cost something under 3*s.* a piece.

Captain BLAKELY: I think I can answer the question of expense. I have bought a great number, and lead-covered shot will cost about double what an iron shot would.

The CHAIRMAN: This shell would be dearer than the lead-covered shell.

Mr. LAWRENCE: I think not. I think from the report of the Armstrong shell that the cost is about the same as these could be made for. These are cast together, and therefore can be easily manufactured. They require no turning, or planing, or anything of that kind. They can be cast in the chill.

The CHAIRMAN: How do you effect the rifling of that shot?

Mr. LAWRENCE: The base of this shot is lead—the one half of it; the other half is zinc.

The CHAIRMAN: The gun is rifled, and it expands into the groove.

Mr. LAWRENCE: It expands into the groove.

Commander SCOTT: Captain Blakely has fired both iron and lead-coated shot; he knows their relative value, and can give you an account of their difference.

Captain BLAKELY: My own experience would lead me to prefer for small guns a shell very similar to what Mr. Lawrence advocates—that is to say, a shell which will enter the gun easily and expand on the same principle as his; its rear may be either lead, or paper, or wrought iron—it is all the same so long as it expands. But for anything like a large size, or for even anything like a medium size, I think such a shell is totally inapplicable. For this reason, if you let a 12-pounder shell fall on the deck of a ship, it would not be so mis-shapen but that it would go into the gun. But if you let a 40-pounder shell fall, and it gets a dent in the lead, you may get it partly down into the gun; there it sticks, and you cannot get it back again. The expense also is in favour of plain iron shot. The great advantage which lead-based shot have in mere experimental firing, where you do not let it fall, is that you close up the windage; but in a large-sized eight-inch gun the windage need not be so very much greater than it is in a two-inch gun; it is very much less in proportion, and really but a mere film of gas in comparison with the mass of gas which will be acting upon the shell. My own experience leads me to think that for small guns something like Mr. Lawrence's shell would be extremely good; but for large guns I confess I have recently adopted the shell which Captain Scott has so ably produced.

Sir GEORGE SARTORIUS: I do not completely understand what are the great advantages which Mr. Lawrence assumes for his shot over the common shot. Is it penetration?

Mr. LAWRENCE: It is penetration. I contend that this description of shot are very superior to iron shot, for they will penetrate plates much better; that where iron rebound, this will go through. I contend that against an iron-plated vessel an iron shot is perfectly useless, while shot made on this principle will penetrate. It could be very readily proved at a small expense; it could be tried for 10*l.*

Sir GEORGE SARTORIUS: If the experiment can be made so cheaply, and with such results, I am rather surprised that it has not been tried. So far as my judgment goes, from hearing very practical reasonings, I certainly cannot come to the conclusion you have

arrived at; viz., that a combination of soft metals, such as you propose to make, will go through iron where iron shot will rebound. Supposing the two kinds of projectiles fired with the same charge of powder, if the iron shot rebounds, I must confess that I am rather incredulous that yours will go through.

Mr. LAWRENCE: The thing has been actually tried at Shoeburyness; and, if you refer to the Iron Plate Committee, they will acknowledge, I have not the least doubt, that it did actually penetrate a piece of iron.

Sir GEORGE SARTORIUS: You mean through an inch plate?

Mr. LAWRENCE: Yes, through an inch plate; and it was stated here, and acknowledged by Captain Halsted and by Colonel Lefroy, that, up to the time of my making the experiment, no shell in the service would penetrate an inch of iron.

Commander SCOTT: I am sorry to rise again, but I think that is a great mistake. Captain Halsted, if he made such a statement, was certainly mistaken, because a 68-pounder shell will go through an inch plate very easily, and also through a two-inch plate; but it would be picked up broken on the inside, just as your shell was. I may further be permitted to give my opinion as to why the two metals you use are totally inapplicable for shells for guns of large calibres; and, after all, nearly anything will answer for small guns. It has been found in practice by Sir William Armstrong—although he has the lead so closely confined, as already mentioned, that it cannot well escape—that, if he uses a larger charge than about one-eighth the weight of the shot, he loses accuracy; and that, if a stronger powder be used, the shot cuts its way out across the grooves. Expanding projectiles also, which answer well with a small charge from a weak gun, if put into a strong gun and fired with a greater charge, are expanded irregularly. With a soft metal in front and a softer metal in the rear, the powder capacity in the centre must be extremely small to prevent crushing up. In fact, you would blow the iron chamber right through the shell if the centre cavity containing it were large, and this would be more likely to occur as the size increased; so that, with a large shot, you could not get a proportionately large powder capacity. Again, Mr. Lawrence says that, because his shots are soft, therefore they will do more harm to an iron plate than if they were hard. Now, such a thing cannot be correct; for shot of the hardest iron or steel are always found to do more damage than shot of a softer metal. He has also pointed out that the yielding properties of the soft metal shot when in the gun give it great advantage.

Mr. LAWRENCE: No; out of the gun.

Commander SCOTT: I think you said in the gun, and I wish to take it in the gun first. The soft metal, if it meets with any obstruction in the gun, will, I believe you said, easily change its shape. Granting this, it is clear that the ball, on impinging on a plate, will with readiness change its shape and become flattened down, and then a great portion of the force of the blow would be absorbed in effecting this change, and the edges which ought to cut their way into the iron would be gone. The iron shot, on the contrary, will not yield, and, from not yielding, will go through the plate. The fact being, that, if the shot of a 68-pounder does not break up, it generally goes through the plate at short distances; whereas, if the shot does break up, it does not go through the plate. If you were to fire a 68-pounder wrought-iron shot, reducing the present excessive windage, I believe it would go through the plate without any difficulty whatever.

Sir GEORGE SARTORIUS: What sized plate?

Commander SCOTT: Four-and-a-half inch plate.

Sir GEORGE SARTORIUS: What range?

Commander SCOTT: At 50 yards; you can only penetrate them at all up to the distance of 200 yards. It has been found in the firing that, when the 68-pounder shot have not broken up, they have generally gone through; and, of course, if they do break up, they do not; but, if you want to cut through a plate with certainty, you must have a cutting edge. Here [pointing to a flat-headed shot] you have a sharp circular edge that will certainly cut the plate if a high velocity be given to the projectile; and you may have a powder chamber in its rear. This is, I believe, the sort of combination of shot and shell that is likely to be used in future warfare against iron ships, because you could first cut through the ship's iron sides, and then there would be the shell in the rear to explode afterward.

The CHAIRMAN: I think that is the form of the Russian shell.

Commander SCOTT: I was not aware of it. I gave a sketch of it, as proposed by me in 1859, in my last lecture, but did not dwell upon the matter.

The CHAIRMAN: I may be mistaken.

Commander SCOTT: The advantage of the combination is so self-evident that when people

come to study the question and to understand the principles of warfare they can scarcely help arriving at similar conclusions. I may repeat one thing that I have said on a previous occasion, that I believe the value of lead coating in making the shot cut its way through numerous grooves, was a proper matter for consideration in the infancy of rifling; but now that we have so much more knowledge, and possess such mechanical facilities, we ought to have no difficulty in rifling the guns and fitting the shot without making it rifle itself by cutting its way through the grooves. This is what is really so detrimental to the breech of the Armstrong guns, as it increases the time the chamber remains under the action of the powder before the shot starts, whereas the great point is to get your shot to start as easily as possible. I do not, however, quite agree with Mr. Lawrence in the nice distinction between soft soap and grease as a means for effecting this, nor do I think that the use of either has much to do with the bursting of any gun, though perhaps the shot might be made to slip out a trifle easier.

Sir George Sartorius: But does not that form of shot, the flat-headed, impede its flight?

Commander Scott: The flat front does impede its flight to a small extent; but in no case can the present gun penetrate an armoured ship's side as far as 600 yards. I believe we shall get much more powerful guns, but at present we have nothing that will punch through a ship's armour unless close to it. There is one point which seems to me worthy of attention by every one interested in rifling, which is, that the air in front of the shot is exceedingly compressed. It is not compressed into a solid, but it is very highly compressed, and your shot is really screwing its way through this compressed air, just as a gimlet is screwed into a board, and it meets with a similar kind of resistance. I leave you to investigate this, but I believe such is the case, and Mr. Whitworth has proved that shot fired from a bore rifled with a sharp twist have a longer range than others fired from a less spiral. There is, however, a curious fact, which is, that flat-headed shot will go through water, while round-headed shot will not, as Mr. Whitworth proved. We do not yet fully understand this matter, for we have made so few practical experiments that our knowledge is very confined, and our data on most gunnery questions consist of loose generalities.

Mr. Lawrence: I have only one more observation to make. I think theoretical observations ought not to go against proof. I can only say that one of these soft shots has been fired and taken up again, put to rights, and fired a second time—an 80-pounder fired at a long range. Therefore, it can be readily rifled to fire in the way Captain Blakely alludes to. Now that we are getting iron-plated ships, it is of most vital consequence to us to know whether it is true or not that shots of this kind will or will not do more than iron. Other nations will not be bound by our judgment, and, if by an unfortunate fatality it should happen that this shot is more effective than an iron one, we shall be under the disadvantage of having to contend with superior projectiles, because we do not choose to go to the trouble of making them better ourselves.

The Chairman: I am sure we are much obliged to Mr. Lawrence for coming forward and giving us his views on this subject. These are new matters, and just in proportion as they are new they are liable to meet with objection. The differences that have arisen, generally speaking, arise from the difficulty of getting at facts. Nothing is more difficult in all these experiments than to get at facts. Persons jump to conclusions without having sufficient data. That, I apprehend, is the great cause of the difference. Captain Halsted says that certain shot broke up on a $\frac{5}{8}$-inch plate. It was a fact, but it was not a relevant fact, and he immediately jumped to the conclusion that all shots would break up on $\frac{5}{8}$-inch plates. It was only true that the shot would, under that particular condition, break up. It would be the same with any shot; it would break up under a certain condition. This gentleman has made experiments with a soft shot, which under particular conditions went through. But to condemn iron shot on that account would be, on the same principle, as bad as Captain Halsted's theory—that no shot would penetrate a $\frac{5}{8}$ths of an inch plate. Hence the necessity of experiments being of the minutest kind, because it is so very important that we should arrive at true results. Of course, the theory of this gentleman should have a certain measure of influence; but, really, where it helps us little in questions of this kind, it ought to be put aside altogether, until we get more facts upon which to base a true theory. It does seem, *à priori*, that he has a claim to have these experiments made; and, notwithstanding our learned friends upon such subjects pronounce *ex cathedrâ* against it, I think we ought to have the experiment made. There are conditions on which these metals do unite, and have an extraordinary character; in fact, their character alters altogether. There is no question that the character of soft

metals when combined is very materially altered. Look, for instance, at iron in the condition of smelting. If there is a quantity of sulphur present, its whole character is changed. Take a red-hot iron and put a stick of sulphur against it, and the former will drop to pieces. Such is its strange alteration of character, that when there is much sulphur present a condition is produced that will occasion the rapid breaking-up on ½-inch plates of shot so cast. But that is not to be taken as conclusive against iron shot. Without saying more, allow me to thank Mr. Lawrence for his paper.

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Evening Meeting.

Monday, May 19th, 1862.

His Grace the DUKE OF SOMERSET, First Lord of the Admiralty, in the Chair.

THE CHARACTER OF GUN BEST ADAPTED FOR NAVAL WARFARE, AS GATHERED FROM THE VARIOUS PLANS OF GUNS PROPOSED.

By Captain E. GARDINER FISHBOURNE, R.N. C.B.

MY LORD DUKE, AND GENTLEMEN,—

I will not take up the time of the evening with apologies for having undertaken to read this paper: let it suffice that, having been captivated by the beauty of the mechanism of the Armstrong gun, its great ranges, reported accuracy, and the undoubted genius of its constructor, I incidentally gave in this place a too unqualified assent to all that had been claimed for it. Finding that in some respects I had been misinformed on a point of such national importance, it became my duty to give equal publicity to my withdrawal of that assent.

To compare results obtained from an elaborately finished rifled gun, fitted with an accurate sight, a nicely adjusted missile, added to a carefully devised carriage, and elevating screw, with results obtained from an ordinary smooth-bore gun, without any of those advantages, firing an imperfect missile having a large amount of windage, yet, on that comparison, to found an estimate of the rifle *principle*, as contrasted with that of the smooth bore, was obviously incorrect—still more incorrect to give practice

at ranges, that were as favourable to the rifled gun, as they were unfavourable to the smooth bore. *No fair* estimate of the *principle* could have been arrived at, till equal genius had been expended in developing the merits of each *principle*.

The evils that arise from such a course, even in holiday practice, are great, but they are all intensified by the circumstances of warfare, owing to which, as Colonel Fox has justly observed, the inaccuracies of the man are as 20 to 1 of those which result from defects in his rifle; and if so in the field, how much more so afloat, where, in addition to the causes of inaccuracy enumerated by that officer, are superadded the motions of the ship. How *very* incorrect then must it be to consider a gun apart from the normal circumstances under which it will be used; yet, such has been done; a comparative estimate of the *principle* of the rifle, and of *that* of the smooth bore, has been made irrespective of that which, when the guns and objects are in motion and the distances unknown, must rule their useful qualities, viz. the form of trajectory and the straightness of ricochet.

For the inaccuracies arising from motion, whether it be that of pitching, rolling, or of transit across line of fire, or of rapid change of distances, or smallness of height of the object fired at, are best provided against by a flat trajectory and a ball that will ricochet straight—these will be more nearly attained in proportion as the time of flight, for the required distance, is reduced, and the ball more perfectly spherical, while the smashing effect will be increased in a higher ratio than even the square of the increased velocity.

Greater accuracy with the same guns, &c. at known distances, with heavier charges, arising from the greater velocity of projectile, is so well known and admitted, as not to need proof or explanation; but, great as are the other advantages of high charges, they are small as compared with those of a flat trajectory, where the distances are unknown.

A diagram will best illustrate this:—Plate I., fig. 13, represents two trajectories, one, that of a ball with such a velocity that it travels the distance in one second, and subject only to the fall of 16 feet; the other, of a ball that requires two seconds, therefore subject to a fall by gravity of 64 feet.

If no disturbing cause arises, a ship that is but 12 feet high, and there are few so low, will be struck at any point in the trajectory of the ball, with high velocity; whereas a ship 48 feet high or more, will be passed over by the ball having the lower velocity, and only within narrow limits of distance would a ship 30 feet high be struck by it in *its* trajectory.

High charges and high velocities are most valuable for accuracy under the circumstances of *actual* warfare; uniformly so when, as in naval warfare, the changes prevent the distances from being known, and where the varied motions of the gun-platform prevent any tentative process by which the distances might be even approximately estimated.

High velocities are rendered indispensable by the introduction of iron-clad ships. This is clearly shown in tables A and G, from which it appears that the old smooth-bore 68-pounder, with all its defects, is more effective than the carefully devised 110-pounder Armstrong, demonstrated by the greater penetration and greater indentation of the shot of the former.

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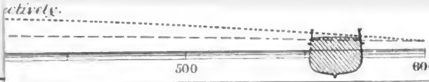

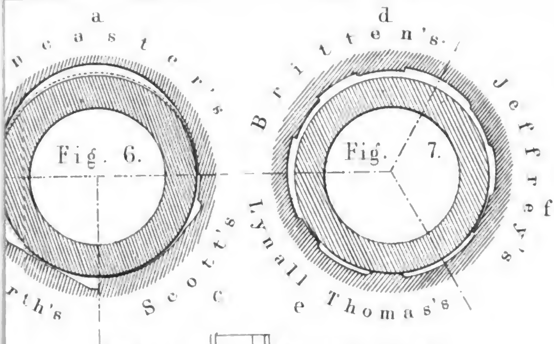

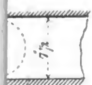

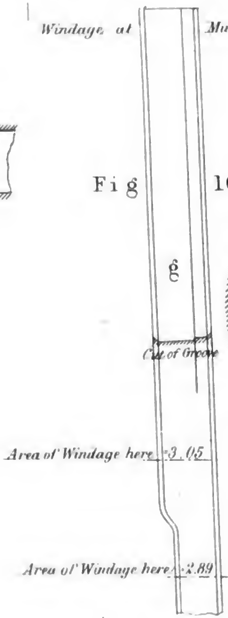

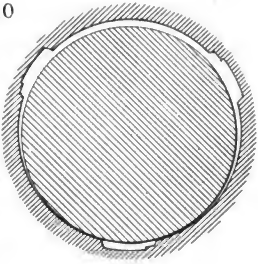

Fig. 9.

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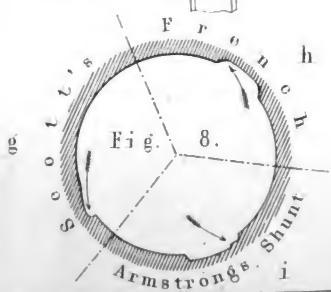

J.R.Jobbins

TABLE A.

Obtained by measurement at Shoeburyness.

Nature of Gun.	Shot.	Powder.	Penetration.		Comparative Force of Blow, exclusive of Width.
			Depth.	Width.	
	lbs.	lbs.	inches.	inches.	
Old 68	68	16	2¼	7½	5·06 } Cast Iron Shot.
Armstrong	110	14	1½	—	2·25 }
Ditto...	200	10	¾	6½	0·56
Old 68	Shell. 50	16	1½	11	2·25

FAIRBAIRN TARGET.

TABLE G.

Nature of Gun.	Distance.	Powder.	Thickness of Plates.	Penetration.	Remarks.
	yards	lbs.	inches.	inches.	
68-pounder ...	200	16	4½	2¼	Obtained at Shoeburyness.
,,	,,	20	,,	3	} From H.M.S. Excellent.
,,	,,	24	,,	3·4	}
*,,	400	16	4	3	} Wrought iron shot.
*,,	,,	,,	,,	went through.	}
*,,	600	16	10	1½	Thornycroft's plates.
*Armstrong 80-p....	,,	11	,,	1	
*Ditto 40-p. ...	,,	5	,,	¾	

* Compiled from official reports.

As it is generally admitted that the highest initial velocities can be obtained only with round shot, it is hardly necessary to offer proof: still the tables B, C, and F, set this forth in a clear light; these show not only that the initial velocities of round shot are greater, but that the time of flight for the most essential ranges is much less; by essential ranges, I mean those within which the iron clothing of ships may be materially damaged, up to 600 yards or more if the plating be thin, still further if the guns be increased in size.

TABLE B.

OFFICIAL REPORT.—Velocities obtained by Capt. Andrew Noble, R.A., with Narvez's Ballistic Pendulum.

Nature of Gun.	Powder.	Projectiles.			Velocity at 30 yards.	Initial Velocity.	Remarks.
		Nature.	Weight.	Diameter.			
	lbs. oz.		lbs.	Inches.			
32-pr. rifled shunt, 59 cwt. ...	5·8	Plain shell.	54	6·35	1215·7	1224·5	Solid zinc bearings. —E.G.F.
32-pr. 59 cwt., smooth	5·8	Cylinder.	54	6·35	1187·4	1201·0	
12-pr. A. 6 cwt.	1·6	Plain shell.	11·9	3·074	1103·4	1111·8	
12-pr. 6½ cwt. ...	1·4	Common shell.	8·12	4·55	1124·2	1163·4	
12-pr. A. 8½ cwt.	1·8	Seg. shell	11·9	3·084	1180·9	1190·2	
	1·8	—	11·9	3·074	1238·3	1248·2*	Experiments to ascertain the effect of diminishing lead on base of 12-pr. Armstrong projectile.
	1.8	—	11·9	3·010	1200·0	1209·7†	
68-pr. 95 cwt. ...	16.0	Round shot.	66·4	7·91	1553·3	1579·0	
			51·8	7·91	1769·4	1809·9	
32-pr. 58 cwt. ...	10·0	Solid shot.	31·6	6·17	1653·0	1690·0	
12-pr. 18 cwt. ...	4·0	—	12·10½	4·52	1718·0	1769·8	

* Shell fired under normal circumstances.

† Same shell, lead reduced to the same diameter as the gun, except 0·25 of an inch at the base.

TABLE C.

Description of Gun.	Point Blank Range.	Height of Platform.
	yards.	
68-pounder, 95 cwt. (smooth bore)	310	8 feet.
*68-pounder, 112 cwt. (ditto)	400	8 feet.
100-pounder Rifled Armstrong	345	17 feet.
13-inch Horsfall 280-pounder (smooth bore)	600	20 feet.

* Service charge of this gun is 20 pounds of powder.

TABLE F.

Royal Artillery Practice Cards.

	$\frac{1}{4}°$	$\frac{1}{2}°$	1°	2°	5°
Brass 9-pounder, charge 12lbs. 8oz.	400	500	700	1000	—
Armstrong 12-pounder charge, 1 lb. 8oz. ...	150	300	560	993	—
	Fired from own field carriages.				
Armstrong 12-pounder...	—	—	—	1130	2146
Whitworth 12-pounder...	—	—	—	1198	2368

Fired 17ft. above plane.

Armstrong and Whitworth competition with service charges, powder $\frac{1}{8}$th weight of projectile.

Whatever, therefore, may be determined on as to smooth-bore guns, round shot cannot be dispensed with, especially when the calibres are further increased, for elongated shot cannot be driven with equal velocity; their greater weight, and the friction on the lands, or wings, to give them rotatory motion, must always prevent their attaining very high velocities, nor can it with reason be said, that the charges with such shot can be increased to the amount used with the round shot, since the increased tension which that would entail would destroy any gun yet made, and likewise destroy many descriptions of rifle projectiles.

Table (B) of experiments is offered, in proof that there is no more friction in the shunt rifled gun than in the smooth bore, but that is simply impossible. The shunt rifled gun nips its missile as it passes out, for the purpose of obtaining greater accuracy, but if there is no greater friction there can be no nip and no directing power. It is but too palpable that there is a destructive amount of friction, and a retardation of the bullet near the muzzle of the bore, and from the shot being elongated, the powder is exploded under greater pressure, and a more elastic gas is generated, which, counterbalancing much of the force absorbed by the friction, may hide in part its existence from view. That the gas under such circumstances is more elastic, is proved "by the fact, of the back action increasing with the angle of elevation, and the initial velocity of round shot increasing with it *pari passu.*"

The friction and consequent increase of tension prevents the powder charge from being increased in any of our present rifle guns, so as to obtain an effective initial velocity.

Had the powder been increased, the shunt shot would have stripped, or the gun itself would have yielded. But the fact is, the table does not supply data sufficient from which to form a correct estimate, and there is no parallelism between a cylinder with its large frictional surface, and a round shot, which rests upon a point and at once rolls in the bore.

And yet the experiment with the cylinder mentioned in Table B is

given as a proof that there is no friction in the rifled gun, overlooking two important elements wanting to constitute it a scientific experiment, viz., absence of equality of windage and of tension on the gun; the latter must always be the starting point, as that must determine the quantity of powder.

The argument that the smallness of the recoil of rifle guns, establishes that there is little friction, and therefore little tension on the gun, is a fallacy, for it is the intensity of the friction that prevents the gun from recoiling; so great is it, that it could not fail, with higher charges than those used for *them* now, in time to disintegrate such guns, by separating the chase from the breech, or more properly the inner cylinder from the outer; indeed, I believe this has already in many cases taken place.

The friction of some of the rifle projectiles has been estimated as absorbing nearly half the power of the powder burnt, all which goes directly to injure the gun.

The retardation of the shot, of which there can be no question, is an undeniable proof of the existence of the greater friction of rifle projectiles and of the increase of tension which it occasions to the guns.

The evil of retardation of the shot in ships' guns is so great, that it is a serious objection to any gun in which it occurs, as it becomes, from various causes common to ships, a very large element in inaccuracy—as, for instance, from the rolling motion, and the form of the decks, the effect of which would be similar to a jump from a violent recoil, or from the absence of a just preponderance, producing errors both in elevation and in direction, proportionate to the amount of the retardation.

Since I wrote the above, the following extract has been placed in my hands, in which are summed up the results of some experiments:—

"The 68-pounder was loaded and fired five times, *very good shots*, the distance being about 2,000 yards; while the 100-pounder Armstrong was loaded and fired three times, and, from some unaccountable reason, *very bad shots*, yet they were laid very well, so that in a seaway, or where at least the ship is rolling like the gun-boats do, 25° altogether, the 68-pounder pivot-gun beats the Armstrong 100-pounder completely. Such was the opinion of all who were there and saw the firing. I suppose on shore the Armstrong is best, but not at sea." The extract bears the impress of truth, and that the writer was not prejudiced, for he deems the result as unaccountable, while I, under the circumstances, consider that none other could reasonably have been expected. This leads us to the conclusion that, with care in the improvement of smooth-bore guns and their missiles, we may obtain sufficient range and greater accuracy afloat than with rifled guns, while the former would possess what the latter is so wanting in, viz. smashing effect at short ranges.

I take this view, though it may be said to be retrograde. It is not so, however; rifling evades the difficulty by making others, which at short ranges are very much greater; in fact it destroys effectiveness against iron plates. Now I only propose that the causes of the errors in round shot shall be directly removed. These are: an undue amount of windage, imperfect sphericity, and absence of homogeneity. The following tables show how much may be effected by a reduction of the windage. Table D shows the effect of the reduction of windage:—

TABLE D.

Nature of Gun.	Length.	Weight of Powder.	Windage.	Elevation.		
				1°.	2°.	5°.
	ft. in.	lbs.	parts of inches.	yards.		
*32-pounder, 56 cwt. ..	9 6	10	·233	700	1130	1964
32-pounder, 40 cwt. ..	8 0	6	·175	‡731	—	—
32-pounder ,,	,,	,,	·175	715§	—	—
56-pounder, Monk, 97cwt.	11 0	16	·175	†930	1340	2200
‖110-pounder Armstrong	—	12	Nil.	530	920	1970

* From Aide Memoire to the Military Sciences.
† Handbook for Field Service
‡ Height above plane 15 feet.
§ ,, ,, ,, 8 ,,
‖ From Royal Naval Official Ranges.

Table C *a* (Appendix) shows the range at first grazes at point blank, it shows also the comparative initial velocities.

Table E, showing results obtained in America, appears to demonstrate that the windage of smooth-bore shot might be reduced still more, with satisfactory results as to accuracy, increase of initial velocity, and, therefore, of smashing effect, without, from a certain point, increase of tension on the gun; and, as the injury from lodgements arises from large windage, its reduction would increase the lives of guns.

This table establishes in a striking manner that the friction of, and tension on, these rifled guns must be very great, or the initial velocity of their shot would be very much greater; ·170, which is less windage than that of the smooth-bores in the naval service, gives a range of only 52 yards as compared with 288 with only ·025 windage.

TABLE E.

AMERICAN EXPERIMENTS.

From Simpson's "Ordnance and Naval Gunnery," used as a text-book in the U.S. Navy.

Kind of Powder.	Range in Yards.	Pressure on Plug.	Pressure per square inch in lbs.	Diameter of Ball.	Windage.
		lbs.		inches.	parts of in.
Dupont, 30 ...	288	301	1·179	5·63	·025
	92	331	1·297	5·535	·120
	52	207	811	5·485	·170

Tables C and C *a* (Appendix) show ranges and particulars of Horsfall's 280-pounder; this Table shows the point-blank range as compared with those of the Service 68-pounders and Armstrong 110-pounder. The 68 appears to a disadvantage; its range was taken at a height of only 8 ft., the other two, Sir William Armstrong's at 17 ft, and Horsfall's at 20 feet. This would make a considerable difference in their range against that of the 68-pounder. The time of flight of Horsfall's smooth-bore is about half that of the other, and shows abundantly, to what perfection smooth-bore guns may be brought. The windage in the 68-pounder is ·198, that in Horsfall's is only ·08, the effect of which may be gathered from the American results.

In the field it is admitted that the difficulty of judging distances, and other disturbing circumstances, are such, as to confine the ranges of projectiles for military purposes to 2,000 yards; afloat, the disturbing causes, *which are constant*, are greater, from which the various movements in rifle sights become causes of error, therefore the most useful ranges cannot be greater than those obtained by Mr. Horsfall's gun at little above point blank, and with powder only one-sixth the weight of shot, while the elevation of rifle guns is considerable for the same distances. Then, as the angles of descent are great, the chances of striking an object are scarcely worth the powder used. The smashing effect of this gun would be three times that of the 150-pounder.

The former conclusion Sir H. Douglas arrived at *some time* since, for he says,—"The main principle which should govern our choice of naval guns is, to prefer those which with equal calibre possess the greatest point-blank range." This was the correct view to have taken before the introduction of iron-coated ships; since that, we have no choice, as no other guns will be completely effective against iron plates, if against other ships either.

Imperfect sphericity, another cause of error in round-shot, may be removed in working scrap-iron into wrought-iron shot, made requisite by the introduction of iron-plated ships; a nearer approach to homogeneity will at the same time be made, while the expense of such, will still be far below the cost of any of the elongated shot.

Since this paper was written I have seen a pamphlet on this subject, in which the value of smooth-bore guns and improved shot are set forth. It is by Mr. M. Scott, C.E., and shows the turn which the public mind is taking.

To the extent that we have adopted rifle guns, to the exclusion of smooth-bores, for the navy, we have given up the substantial advantages of low trajectories, straight ricochet, smashing force, simplicity, and economy, for the very occasional advantages of long range. Therefore, for efficiency, no less than for economy, we must revert to the smooth-bore in principle, and invest talent and money to develope its merits.

But rifle guns and elongated shells, especially of small and medium calibre, have decided advantages, because of the greater quantity of powder these shells are capable of containing, and long range is also sometimes very important for the support of troops and for breaching purposes; we should therefore endeavour, if possible, to combine the advantages of the round-shot with those of the elongated, in one description of gun; but even for the simplicity which this would bring with it, no sacrifice of initial

velocity is admissible. So that, unless a mode of rifling can be found, that will not involve undue windage, we must have both descriptions of gun, in numbers proportionate to the relative importance of each: little windage, then, must be the ruling qualification in the selection. Such is that proposed by Captain Scott, R.N., such is that used by the French in their rifled gun that admits of the use of round balls. It should be a muzzle-loader, simple of construction, strong, and as little liable to get out of order as possible ; for neither ships nor fleets can take factories to seawith them.

This would exclude all multigrooves, or those with a sharp-edged rifling, which would be destroyed by the passage of round shot over the lands.

Breech-loaders would also be excluded, for they would be too weak in the breech to stand the high charges necessary, and they are dangerous; their greater weakness will be seen by a glance at Plate I. fig. 2, which represents the Armstrong breech-loader, in contrast with Plate I. fig. 1, which represents a 200-pounder gun of Captain Blakely. Thus, in fig. 2, the entering the cartridge, &c. from behind, entails a bad form of chamber; the squareness of the end of which, in Sir William Armstrong's gun, is a proved cause of weakness, as is evident from a comparison of that shown in fig. 3, which is a form known to add to the endurance of the gun. The holes for breech-screw and breech-piece further greatly impair its strength; indeed it seems impossible, with so many parts subject to the action of highly elastic gases, that a gun thus constructed, could be otherwise than weak, and extremely liable to injury.

The coils are shrunk on hot; the metal, of course, contracts in every direction, consequently the joints open; it were impossible they should be close; the *overlapping* pieces at the joints indicate the knowledge of this defect. All these are points of weakness, and the whole of the great vibration which takes place every time the gun is fired must be thrown in turn on these separate parts, and not distributed, owing to the continuity being broken, which must lead early to the disintegration of the gun.

The maximum initial velocity being of necessity the primary consideration, when the smallest increments of time involve the whole question of hitting or not, and always diminish the chance of doing so, lead-coated shot cannot be safely used, nor those either where lead is expanded or compressed into grooves, for the charges required to give high velocities, would certainly force these missiles through the gun without their taking the rifling, causing them to strip; and to use hardened lead on the compression principle with high charges, would inevitably prove fatal to the piece; the liability of leaden missiles to become out of shape by falls would, when it occurred, as is too probable on board ship, increase much the difficulty of loading from the muzzle, and also the danger of bursting the gun.

High charges also would crush up compound shell, and damage the bore near the chamber even more than is the case now, which is so much so in the expanding rifle projectiles, that the grooving at the seat of the projectile is after a time obliterated. The uncertainty and danger of these is such that it becomes a question whether, even for special though unfrequent service, they should be used on board ship.

It has been set forth as a merit that such guns are economical because of the small quantity of powder required for them, covering up the fact, that the sum saved in powder is more than doubled in the cost of the shot.

APPROXIMATE PRICES OF ARMSTRONG AND SMOOTH-BORE SHOT.

	Description of Gun.	Charge.	Cost of Shot.	Cost of Powder.	Total.
		lbs.	s. d.	s. d.	s. d.
Armstrong	110	14	17 0	9 4	26 4
Smooth Bore	68	16	3 0	10 8	13 8
Armstrong	40	5	8 0	3 4	11 4
Smooth Bore	·32	10	1 5	6 8	8 1

It cannot be economy to sacrifice efficiency, and such guns are valueless against iron plates.

The Whitworth gun, though giving satisfactory results with long ranges, under circumstances seldom or never occurring on board ship, is still open to many serious objections.

The angles of its missile in the process of rotation, press against the inner surface of the gun, and cut into it, tending to rip it up.

Lastly, it is unsuitable for round shot, as the angles, as may be observed from Fig. 6 *b*, would necessarily entail a great loss of power by the escape of gas; the shot also would be proportionately small for the same reason.

The Lancaster oval, Fig. 6 *a*, would be very dangerous with large charges, and it also is unsuitable for round shot; the loss of power by the escape of gas would be very great, but a more serious objection is, that the use of round shot and high charges would destroy the gun very shortly.

Without enumerating all the rifle guns, it appears to me that the claim to superiority lies with the three-grooved guns, the others being thrown out, by the large portion of the bore that is cut away by many grooves, or by wide grooves, entailing weakness and undue windage.

Figures 6 and 7 represent sections of different rifle guns drawn to scale; a round ball is placed in the bore, and show the amount of windage that the use of such, would entail in each kind respectively, very large in Lancaster's and Whitworth's, and least in that of Captain Scott. Captain Blakely has abandoned his, and has adopted that of Captain Scott in the guns he has made for foreign governments. Plate II. fig. 18, shews the effect even more distinctly. Suppose the rectangle *a* to represent the whole of the inner circle of the cylinder of the gun, then the smaller rectangles *b*, *c*, *d*, *e*, *f*, *g*, *h*, represent the quantities of this circle required to be left untouched in rifling, according to the respective plans named.

The total amount of windage occasioned by the different systems of rifling, when the present round shot are fired, is given in table H.

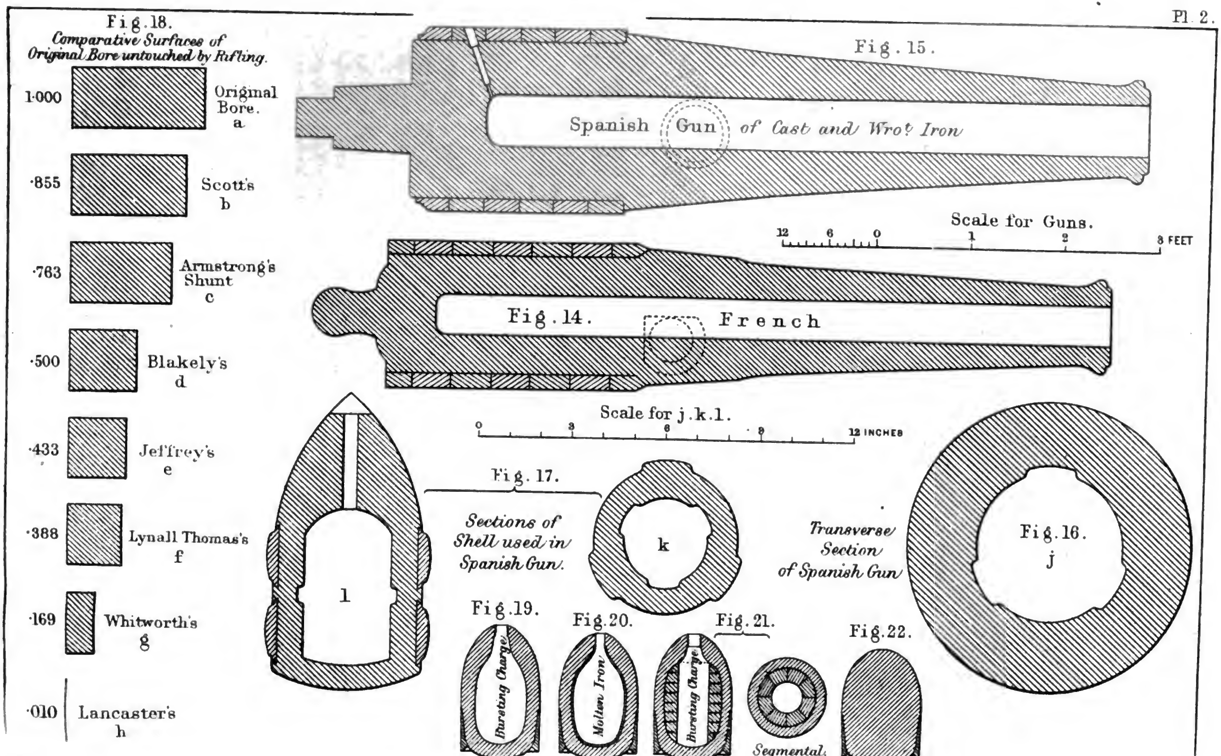
Fig. 18.
Comparative Surfaces of Original Bore untouched by Rifling.
1·000
Original Bore. a
·855
Scott's b
·763
Armstrong's Shunt c
·500
Blakely's d
·433
Jeffrey's e
·388
Lynall Thomas's f
·169
Whitworth's g
·010
Lancaster's h
Fig. 15.
Spanish Gun of Cast and Wrot Iron
Scale for Guns.
12 6 0 1 2 3 FEET
Fig. 14.
French
Scale for j.k.l.
0 3 6 9 12 INCHES
l
Fig. 17.
Sections of Shell used in Spanish Gun.
k
Transverse Section of Spanish Gun
Fig. 16.
j
Fig. 19.
Bursting Charge
Fig. 20.
Molten Iron
Fig. 21.
Bursting Charge
Segmental.
Fig. 22.

TABLE H.

Diameter of bore	6·375
Diameter of round shot	6·177
Windage	·198

	Area of Bore.	Area of Round Shot.	Area of Windage.
Original bore	31·92	29·97	1·95
Scott's	32·24	"	2·27
Britten's	32·55	"	2·58
Armstrong's shunt	32·97	"	3.00
Jeffrey's	33·07	"	3·10
Lynall Thomas's	33·34	"	3·37
Whitworth's	34·62	"	4·65
Lancaster's	34·73	"	4·76

The above results have been obtained by measurements from the guns.

There are three guns with three grooves—the Shunt, by Sir William Armstrong; * the French gun; and that of Captain Scott, of the Navy. (Plate I. fig. 8.)

In the shunt gun the grooves are double, with sharp edges (Plate I. fig. 9); the rotatory motion of the shot is produced by zinc ribs, which run in the grooves—slack going in, to facilitate loading, tight coming out. For greater accuracy, the rifling diminishes in diameter towards the muzzle, to nip the ribs (fig. 10); this necessarily increases the tension on the gun, to which it must prematurely yield; also, there cannot fail to be uncertainty from unequal yielding of the zinc, and a great danger that, with high charges, the ribs would strip off. The missiles would be delicate for the rough usuage of ship service, and the feeling that shot might strip would have a very bad moral effect. The bearing side of the groove ot the French gun (see fig. 8 *h*) is not unlike that of Captain Scott's (fig. 8*g*); the preference is due, however, to the latter, as the direction of the friction is less injurious to the gun.

Again, the rotatory motion of the French missile is produced by studs of soft metal, which are liable to injury, and would certainly fail under the pressure of high charges, and when bent, are liable to burst the gun.

* *Sir William Armstrong.*—You have no correct section of the shunt principle there?
Captain Fishbourne.—Mr. Vavaseur kindly measured all the guns, and drew them for me. He will establish the correctness of his measurements.
Sir William Armstrong.—He cannot: there are no measurements given.
Captain Fishbourne.—The measurements are given in table H.
Sir William Amrstrong.—Then in the diagrams you are showing, there is a far larger space in the grooves than actually exists.

The rotation of Captain Scott's shot is obtained by ribs cast on the shot; they are simple, strong, little liable to injury, and cannot fail; better to steady and direct the shot, and give greater accuracy than studs. The edges of these ribs are softened off by a coating of zinc, giving them any advantage that may belong to soft metal, without the disadvantage.

g fig. 8, represents the shoulder of Captain Scott's; the friction, which is in the direction of the circle, bears against it, whereas, owing to the nipping of the shunt, the pressure is directly outwards, tending to burst the gun, *i* fig. 8. If there is no friction, there is no directing power.

No doubt round shot might be fired from these three guns, as also that of Mr. B. Britten, and, indeed, others; but the loss from windage through the many or deep grooves would prevent round shot attaining a sufficiently high velocity. The many grooves and the wide grooves, impair the strength of the gun, while the narrow lands would soon be eaten through by the friction (*d*, *e*, *f*, fig. 7).

Nor can the evil be remedied, for with increase of powder the grooves must be deepened, or the soft metal will strip or ride over the lands without taking the rifling. By the system proposed by Captain Scott of having strong iron wings, as it were lubricated by a soft metal, great initial velocity for a rifle may be obtained; the mode of rifling being least injurious to the strength of the gun. His missile being also the strongest, simplest, cheapest, and least liable to injury, possesses the strongest claim to be adopted as the naval pattern for a rifle gun.

I might have gone into many details interesting and important in their degree, but *un*important till the question of principle was decided. To that I have endeavoured to confine myself, and I feel sure the discussion were better thus confined. I have satisfied myself, and can only wish I may have satisfied my audience, that with round shot (perhaps it may be with smooth-bore guns) alone shall we be able easily, safely, and economically to obtain that velocity of flight over short ranges, that shall be effective against iron-plated ships; and that the long-range guns are of more limited value for military purposes generally than has of late been supposed; and, as they are of still less value for naval purposes, it will be matter of grave surprise that so much has been spent in producing guns so deficient in the prime qualifications for good naval guns—viz., 1st. Great initial velocity—no great part of which must be sacrificed to the rifling. 2ndly. Simplicity of construction in gun and in all its appointments. 3rdly. Muzzle-loading, for safety with high charges. 4thly. Mode of rifling to be strong, simple, and least injurious to the gun, or easily injured by round shot, or by any other cause, such as leading, constantly in operation. 5thly. Missiles to be simple, strong, and least liable to injury.

It is due to Captain Scott to say that thirteen months since he strongly insisted in this place on the value of rifled guns that would admit of the use of round shot, and that every experiment in that direction establishes more and more the correctness of the views he then stated. The *Times* in a recent number gives 3 and 3½ inches as the penetration of a 68-pounder with 20 and 24 lbs. of powder, the probability is that the windage of that guns was ·198—far too great; that of Horsfall's gun is only ·080; ·060 would be sufficient; a reduction to half ·198 would produce nearly, if not quite double the effect reported. The cast-iron guns in their present

condition would hardly stand the high tension, but hooping them would be a rapid, effective, and economical way of using up our present stores, and of obtaining an early supply of guns; the propriety of ordering more cast-iron guns is doubtful.

A question here arises as to the construction of the guns: we have seen what danger and weakness arose from violating the law of homogeneity in the breech-loaders; this may not be repeated without grave responsibility, and as we must have high charges at all costs, with increased tension, it seems the undue application of the coil system as in use, will have to be modified, if not abandoned, for forging in whole, or to a greater extent; the forged guns would stand the blow of a shot vastly better than a coil gun. And therefore it is an important consideration as to whether it is worth paying 650*l.*, the price of a 110-pounder, for what at 300*l.* or 350*l.* would suit our purpose equally well on most points, and better on this important one.

As a practical illustration of how the two systems of coils and forging might be combined with advantage I may suggest the following, the result of conversation with practical men:—

The internal tube reaching to the muzzle should be forged in one piece, closed at the breech, of iron approaching to the character of steel, and wrought on a mandrel, hollow; breech-piece, including the trunnions, should then be brought over; lastly, over the chamber there should be a coil, to give more tensile strength to resist the effect of explosion.

The question is one of great national importance, both in an effective, an economic, and commercial point of view, so great as to justify us in calling on those gentlemen who have displayed so much talent in working out their respective plans, to look at the question less from a personal and more from a national point of view, and agree to differ as to the respective merits of their respective plans, and, while differing, agree to join in producing the gun best suited to serve their country's interests.

The Duke of SOMERSET: Gentlemen, I am sure you will all agree with me that at any rate this is a most important question to be considered, and that we ought to be greatly obliged to the gentleman who has opened this discussion for us. Now that it has been opened, I hope the discussion will be carried on by those who have considered the subject fairly and calmly. For myself I would say this, that I have read a great deal and heard a great deal about guns of all kinds. Of what I have heard there is a great deal I do not believe, and very little that I do believe. What we want is to get some progress. I have not yet heard distinctly whether you intend entirely to give up the cast-iron gun, or whether you take entirely to the wrought-iron gun. Whether you object to the rifled or the spherical ball bore is another question; but I should like to hear from those who have considered the subject some little progress. I believe we shall get that progress best by just calmly talking over the matter.

Vice-Adm. the Honourable Sir FREDERICK GREY, K.C.B.: As Sir William Armstrong is here, perhaps he would have the kindness to explain to us some of the points connected with his gun that have been objected to, and that would, perhaps, open the discussion in the most satisfactory way.

Sir WILLIAM ARMSTRONG: The paper which has just been read, embraces such a large number of facts which I feel myself called upon to answer, that I really do not feel able, on the spur of the moment, to go into a complete refutation. There can be no doubt but that this question will have to be adjourned; and it would certainly be more satisfactory to myself, and probably in its results more satisfactory to the meeting, if you would allow me to take a little time to consider the subject. I should be prepared the first thing to-morrow night to give a general statement, not only in refu-

tation of what has been advanced, but also as conveying my own views as to what is proper to be done in regard to naval armaments under the present aspect of the question.

Major-General ANSTRUTHER, C.B. said, the recorded range at ten degrees of elevation of Sir William Armstrong's gun, speaking from memory, was 3,598 yards, and the longest range ever known to be got by a round shot was 3,130 yards. With one-eighth of the shot's weight, Sir William Armstrong's gun got more initial velocity, because it got more range, at the same elevation than the round shot ever attained. (No, no.) He was prepared to maintain it against all comers.

Colonel WILFORD, R.A.; I will explain in a few words why the initial velocity of round shot is greater than that of the Amstrong shot. In the first place it has been determined by the galvanic apparatus at Shoeburyness that the 68-pounder, as a matter of fact, has greater initial velocity than the Armstrong. Now for the reason why. Suppose we take two projectiles of equal diameter, one spherical, the other elongated; the transverse section, or that perpendicular to the trajectory, will be equal in each case; therefore the column of air to be displaced will be equal in each case; and hence the resistance will be the same. But, the elongated projectile overcoming the same resistance of air, has much greater weight behind it to overcome that resistance. Hence it is, that, although a spherical projectile of equal diameter may have a much higher initial velocity at the muzzle than the elongated, yet, suffering a much greater retardation, its velocity is much more rapidly diminished; therefore, in the latter part of its flight it passes more slowly over the ground; hence it does not go the same distance at the same elevation as the elongated, which, although starting at less velocity, preserves it more uniformly throughout its flight.

General ANSTRUTHER was much obliged for the answer. It was the first time he had been able to get an answer. But as the initial velocity was not the subject of discussion, he should not go into it now, except to say that he differed *in toto* from all that Colonel Wilford had stated. To return to the point under discussion, Ought not all these experiments in guns to be tried in brass, because, if condemned, they could be re-melted? Why was it that everybody used the most expensive metal, and hammered out 900 guns, only to find that there was a better gun which could be made? The objection against brass guns was, that they drooped at the muzzle. Now, the drooping at the muzzle was owing to the very injudicious plan of placing the trunnions. Were the trunnions placed close up to the muzzle astragal, there could be no drooping.

General Anstruther here produced the model of a modification of the Prussian breech-loader, which he described, and declared to be the simplest and speediest loading gun in the world.

Colonel WILFORD: I should like to explain why brass cannot be used. In artillery you cannot safely proceed from small things to great, as you can in many other things. A thing that answers perfectly on a small scale in a model, fails on the large scale. Now, I proceed to show in a very few words why an experiment with a small brass gun would be worth nothing as applied to a large gun. Many years ago iron mortars were introduced into the service, and why? Because, when large brass mortars were used, holes were burnt in the chamber owing to the immense heat generated by a large charge of powder acting on the material of the gun metal. The results of the experiments can be seen in Sir William Armstrong's department at Woolwich as conducted by General Sir Thomas Blomfield, formerly Inspector of Artillery. Therefore, if you are to make these experiments on a large scale in brass guns, the heat generated would be so great that the form of the gun would very soon be changed, and your experiment would be comparatively valueless.

Lieutenant-Colonel CLAY, 8th Lancashire Artillery Volunteers: Although I am myself unprepared to speak upon a subject of so much importance, still, having had some slight experience in the manufacture of guns of large calibre, I may perhaps be permitted to make a few remarks, which will be short and to the purpose. I think, in the first place, it will be very desirable that each gentleman who addresses the meeting should endeavour, as far as possible, to avoid treading upon his neighbours' toes, and confine himself to bringing before the meeting any merit which he considers may apply to his own invention or to the particular article in which he is more immediately interested. In the year 1856, during the Russian war, when accounts appeared in the public papers that it was desirable large ordnance should be made, a gun was attempted to be manufactured somewhere in Lancashire by an eminent engineer, that gun failed, and it was stated in the public prints that the reason of the failure was, that, on account of the long continued heat of the mass of metal, the iron was carbonised to such a

degree, that, even if the gun had been made, it would have been weaker than cast iron. We felt that our reputation as iron-masters, making the largest description of forging, was somewhat at stake, and we resolved at once to offer to make and present to Her Majesty's Government a gun as large as, or larger than, the one attempted to be made. The reason of that was, that when so eminent an engineer had attempted to manufacture a gun, and failed, we thought, our name not then being so well known to the public as it is now, that Government would not have been justified in making another grant of public money for us to make a similar attempt; therefore, the only means by which we could get the Government to try the gun, was by offering it to them in such a way, free of cost, that it could not be refused. The gun was made, and was proved on the shore at Liverpool by Major Vandeleur, Instructor of Artillery, who was sent down expressly for that purpose. It was proved with 45 pounds of powder, and with shell loaded with lead, weighing 310 and 318 pounds. This was then thought such an enormous charge for artillery, that the then Select Committee sent charges to Liverpool weighing from 10 to 24 pounds, with instructions that we were to begin with the smaller charges, and, if the gun did not burst, we might proceed to the larger ones. In the absence of the Artillery Instructor, Sir Duncan Macdougal, in command of the Lancashire Artillery, then at Liverpool, placed a gun detachment at our disposal. We began with 10-pound charges, and went on to the 20 and 30-pound charges. When the Artillery Instructor arrived, we had reached the 30 pound charge. He expressed his surprise, and told us it was useless to go on any longer with smaller charges. An experiment was also made, perhaps the first ever made, at the request of the Instructor of Artillery, against a battery-plate of 4½ inches thick. A target was hastily constructed on the shore, steadied with nine baulks of timber about 14 inches square, and firmly imbedded in a bank of sand, which solidified the whole structure. That battery-plate was probably masked in a manner that has never been equalled since. This was in the year 1856. Table *Ca* (Appendix) shows the comparative ranges of the 68-pounder 95 cwt. service gun, and the 100-pounder rifled Armstrong gun, and the 13-inch Horsfall gun, at point-blank range. Each division of this table represents 10 yards. While the 68-pounder ranged 310 yards and the Armstrong ranged 345 yards, the 13-inch gun ranged 600 yards. The data with respect to the 68-pounder and the 100-pounder are taken from the "Handbook for Field Service," published this year. The data of the 13-inch gun is from the report supplied by Colonel Mitchell to the War Office, a copy of which the War Office has favoured us with. It has been remarked, and the remark is a very just one, that the circumstances are not entirely parallel in these three cases—that the 68-pounder gun was fired from a height of 8 feet above the plane, that the Armstrong gun was fired from a height of 17 feet above the plane, and that the 13-inch gun was fired from a height of 20 feet above the plane. This ought certainly to be taken into consideration; but, if we make a deduction from the range of these, to correspond with the height of the plane of the Armstrong gun, we shall have to knock off 90 yards in the range, which will give us a range of 510 instead of 600 for the 13-inch gun as against the 345 yards of the Armstrong gun. I have not made the comparison with the 68-pounder smooth-bore service gun, because after all the 13-inch monster gun is only an exaggerated 68-pounder. The ranges were not merely confined to point-blank range, but up to 10 degrees of elevation, the same guns being taken in the comparison. Up to 10 degrees of elevation we start with a slight advantage over the two other guns; at 12 degrees the Armstrong gun takes the lead, and, as everybody knows who has at all studied these matters, increasingly so, at still higher degrees of elevation. A remark was made just now that no smooth-bore gun ever got a range beyond 3,600 yards; that is simply ridiculous, because this monster gun has had a range of 5,009 yards.

General Anstruther: At ten degrees.

Lieutenant-Colonel Clay: Not at ten degrees?

General Anstruther: That is the statement.

Lieutenant-Colonel Clay: At ten degrees the range is 3,540.

General Anstruther: Which is 50 yards less still than the Armstrong, and it is not a smooth bore.

Lieutenant-Colonel Clay: I can only give the data as I take it from the "Handbook of Field Service," and from Colonel Mitchell's "Report," and I consider, with the explanation about the difference in the height of the plane, we must take them as authentic. With regard to the charges of powder, the charge with the 68-pounder service gun is 16 pounds; with the Armstrong 100-pounder the charge is 12 pounds; and with the Horsfall gun the charge has been 50 pounds. Ninety rounds had been fired out of

that gun with 50 pounds of powder each. The proportion of the charge of powder to the weight of shot, was, in this case, one-sixth. Before manufacturing the gun, reference was made to the late eminent Sir Howard Douglas; I made a journey to France purposely to consult with Sir Howard Douglas. Before we commenced the manufacture of that monster gun in 1856, Sir Howard Douglas's remark, which I have never forgotten, was to the effect, "Give me a gun that will range at point-blank and I do not care anything for any long-range gun, or for any particular benefits that may result from it." He admired and wished to have the most powerful point-blank gun. I may perhaps mention incidentally, with regard to that gun, that I suppose no gun has ever had more powder and shot blown out of it. The recorded experiments, taking the quantity of powder for charges from 10 pounds up to 80 pounds, show that there have been upwards of 7,000 pounds of powder and 60,000 pounds of shot blown out of that gun, and, if a slight defect has shown itself, I should like to be informed where the other gun is, that has blown out anything like the same amount of powder without showing any defect. I am happy to say that at last, after many years' endeavours, we are about to get some measure of justice to that gun. Lord Ripon at the War Office to-day promised that it should be immediately tried, and in its present condition. In visiting it a few days ago at some gun experiments at Portsmouth, I was sorry to find it nearly buried in the shingle, and so rusted was it, that I hardly knew my own child. I find that the officers who proved it, and even the very gunners, who are there still, informed me, although they had no knowledge of who I was, that they have the most unbounded confidence in the gun and I fearlessly challenge the whole country, when I say that that gun as a battery gun is unequalled, and has had more effect than any other gun that has ever yet been made.

While upon this subject, I may, perhaps, say a few words about the forging of guns and building them up. At several meetings such as this held in London, I have almost alone stood up for the plan of making guns in one piece of wrought iron, and I am glad to find at last, that the opinions of many gentlemen who have studied this question are somewhat modified, and coming round to that view of the subject. Whether solid-made guns or built-up guns are the stronger, I care not to inquire into; all I care about is, that the guns I advocate, solid-made wrought-iron guns, are amply sufficient for every useful purpose, and at the same time I believe they can be made at a very much less cost than any built-up guns, with the exception perhaps of guns the principal portion of which is cast-iron, and strengthened by wrought-iron or steel hoops. That is a question which I wish not to enter into, but I would merely guard myself by saying that I do not mean to say that solid wrought-iron guns can be made cheaper than those guns. The question will probably be entered into by the various gentlemen whom I see round me, in dealing with the merits or demerits of cast-iron for ordnance purposes. With regard to the size of the gun, it seems now to be an important question as to what size a gun can be made safely or economically, with the view of being placed in our forts, or, if possible, be carried by our ships. In 1856, the monster gun, weighing 21 tons 17 cwt. was pooh-poohed as a gun too large for any useful purpose whatever, yet I may take this opportunity of observing, that the proportions of which I intended to make that gun were considerably increased by the authorities at Woolwich. Now, there seems to be an opinion that, at any rate in fortifications, guns, if they are effective, can be used of any size that it is possible to make them. I do not know whether I am out of order. I am not much accustomed to be examined by Committees, but upon my examination by the Defence Committee, a few days ago, I had some questions asked me there. Perhaps my Lord Duke would inform me whether I am permitted to make known to the meeting what was said upon that occasion.

The Duke of Somerset: I do not think there will be any danger in your stating it to the assembly.

Lieut.-Col. Clay: I was not aware whether it might be considered private and confidenial. I was asked whether I could undertake to manufacture a gun which would penetrate the sides of the *Warrior* at 1,000 yards. I stated that I should have no hesitation, with our present machinery, to undertake to manufacture a gun that would, in my firm belief, fracture the side of a ship constructed as the *Warrior*, covered with four-and-a-half-inch plates, at 1,000 yards. I was then asked the question whether I would undertake to do it at 2,000 yards. The question became a very different one, and involved so much difficulty that I declined to give any answer upon that subject; but it was there stated, that, if guns could be constructed, it would be desirable to construct them of such a size as to enable them to make a serious impression upon vessels

such as the *Warrior* at 1,000 yards. I believe there would be no difficulty whatever in making them, although the monster gun weighs 21 tons. I have no hesitation in saying, that, with our improved machinery, guns very much larger could be made with equal facility. I should like to say a few words about the method of making guns, as exemplified in the Prince Alfred gun, That gun was forged hollow. In the monster gun, at the end of the breech, as is generally the case when contraction sets in with either cast or wrought iron work of unequal dimensions, a small drawing or shrinkage took place in the bore of the gun. That is in consequence of the gun shrinking unequally; the cooling of the gun from the outside formed a solid arch, and the interior, in consequence of its weakness, gave way. We were not then in possession of so much experience as we have now, about the strength of the breeches of a gun, or that guns could be made upon this principle where a considerable proportion of the breech might be cut away with safety. Therefore, the bore was somewhat shortened, and a piece which we call the plug-piece was placed in the breech at the bottom, leaving most ample strength behind. It was simply to prevent the *débris* from the combustion of the gunpowder getting into the crack and causing the ignition of the next charge when there came to be rapid firing. That was got rid of by the plug. I am informed by the officers and men who conducted the last experiment, when the gun was proved with 80 pounds of powder, impressions being taken before and after two explosions, that no perceptible difference took place in that so-called flaw, and I was informed that the flaw was in the plug, a separate piece that was put in. And, as to the efficiency of the gun as a battery gun, I am informed that there is such confidence among the officers and men who have tried it, that they have no hesitation whatever in carrying on further experiments with it.

A gentleman asked if this Horsfall Gun was cast solid.

Lieut.-Colonel CLAY: It was forged solid and bored.

Colonel LEFROY, R.A., F.R.S.: At this late hour of the evening, I will not detain the meeting more than a few minutes. I have heard from my friend Captain Fishbourne several statements which I think extremely erroneous, and several arguments which appear to me extremely fallacious. In the first place, I wish to set at rest one doubt that has been expressed, in extremely strong language, by Captain Fishbourne, as to the possibility of giving a high initial velocity to a rifle-shot. I am in a position to state that an initial velocity of 1746 feet per second has been given to a rifled shot, with a charge of one-fourth the weight, with an Armstrong gun. On the same principle, we may reasonably conclude that an equally high initial velocity may be given to any other Armstrong gun with one-fourth the charge, the velocities with the service charge being nearly the same. I am far from saying that those guns will continue to stand being fired, an indefinite number of times with that charge. At all events, they can be fired a short time, because it is the habitual proof-charge of the Armstrong gun, and many of them have stood a great many proof rounds. Therefore there can be no doubt about that; there is no doubt they will stand to a considerable extent. I can also set at rest another question, namely, that it is impossible for lead-coated shot, forced through the bore with that velocity, to take the rifling. I reply, in point of fact, they do take the rifling, as can be seen any day at Woolwich, where they are fired with that one-fourth. Again, it is said that the less friction there is in the gun the greater the velocity. Now, we have guns of different lengths, and we find that when we shorten the gun we lose velocity very materially; that is to say, whatever it lost in friction, is more than made up by the time which is given to the powder to exert its entire force. It is a well-known principle in rifling, and I am surprised to hear it questioned at this time of day. Again, a comparison has been drawn between the point-blank ranges of a great variety of shot, fired at different heights above the plane. These point-blank ranges mean the distance from the muzzle to the point where the shot first strikes the sands below. Such a comparison is surely fallacious. The only true scientific comparison of point-blank range is the distance from the muzzle of the gun to the second intersection of the trajectory with the line of the sight. And, when we come to consider what are the real angles at which these shot are fired, it is sufficient to account for the difference of point-blank range. For example:—a shot fired horizontally by spirit levels from a platform seventeen feet high will range say 400 yards, but this shot is really attributable to an angle of three-quarters of a degree. But, when we come to discuss these things with scientific precision, we must be careful to eliminate all the sources of variation, and to reduce them to their proper value. Again, a comparison has been drawn between the 68-pounder shot with

its present initial velocity and what the initial velocity would be, were the windage reduced. Every officer knows we cannot reduce the windage of our guns; we should burst them if we did. Sir Howard Douglas drew attention to the subject in 1818, and no great reduction has been made since. If we do reduce it, we must reduce the charge of the guns. To account for the great difference of range between the late smooth-bore wrought-iron gun, it is sufficient to know, that, whereas the area of the bore through which the gas is able to escape in the 68-pounder gun is one-twentieth of the whole quantity, in the 150-pounder it is represented by ·015. So absolutely necessary is it to bring into comparison all these elements of dissimilarity in the results of guns, before you can draw any satisfactory conclusion. I will not take upon me to defend Sir William Armstrong's guns, or to argue from very erroneous drawings that they must be weak when in fact they are strong; that Sir William Armstrong will do to-morrow. Those guns have given proof of strength which no other guns have given. Perhaps no other guns have been tried in the same way: but the fact has been more than once mentioned that the 100-pounder gun has fired a continuous series of 100 rounds with the service charge, and cylinders increasing from 100lbs. to 1,000lbs., without exhibiting any weakness. On the other hand, forged guns, not on the coil principle, one of them made by Horsfall himself, and I allude particularly to Mr. Lynall Thomas's gun, have after long-continuous firing shown flaws of so treacherous a character, that that gun burst with a weaker charge than the charges with which it had previously been fired with impunity for a considerable space of time, and justifies one in feeling a doubt as to the possibility of forging those great masses; or at all events we may question the evidence of the strength of these great masses thus forged.

Lieut.-Colonel Clay: That gun was made of steel, a new material; it was the first attempt at a gun of that kind, forged solid, according to plans with which we had nothing to do. I mention here publicly, it was burst by the jamming of the shot in the bore. The shot was such as must inevitably burst the gun.

Colonel Lefroy: I was at Shoeburyness on that occasion, and I do not think it burst from that at all. With regard to the exact method of rifling which should be adopted in a muzzle-loader, I should wish to state that the attention of Europe is divided between two systems of rifling. The French, the Spaniards, the Dutch, the Russians, have all adopted the system of muzzle-loading guns. On the other hand, the Austrians, the Prussians, the Belgians, and the Germanic States generally, have all adopted the breech-loading system, to which every objection that can be urged against Armstrong's gun is applicable in a three-fold degree, showing again that the game is not entirely with those who are playing for the muzzle-loaders.

Captain Blakely: At this late hour of the evening I will say a very few words only. In the first place, I will remark, that I was very much astonished to hear a person of Colonel Lefroy's deep scientific attainments state, that, if the friction in the Armstrong gun is very great, therefore it would follow, as a matter of necessity, that the shorter the gun, the greater the velocity, because, if that were the case, if we had no length at all, the velocity ought to be extremely high indeed. The fact is, seeing that friction is very great, and retards the ball, adding length to the barrel does not give so much additional velocity, as would be attained if the friction were not so great. With respect to the materials of which guns should be made, a mere expression of opinion whether wrought iron is good, or brass is good, is valuable; we ought to look entirely to facts. Now, as to the Armstrong or coil system. I have got a book in my hand dated 1845, giving an account of this coil system; it was tried, and abandoned on account of its total failure. The experiment was made by Mr. Treadwell, the President of the American Academy, a man of very high standing in his country. He made guns on that plan, not only in America, but also in France; he made them of a very considerable size. They had not in America at that time the large machinery which we have in Liverpool now, and they only made those guns the size of 32-pounders; they made them nearly as the guns are now made at Woolwich, of little coiled spirals of wrought iron welded end to end. I will read Mr. Treadwell's own words:—"A number of rings or short hollow cylinders are first formed by means of various moulds, dies, and setts connected with the powerful press before alluded to. The rings are upon their inner sides, and to about one-third of their thickness, of steel; the outer portion being of iron, wound about the inner steel ring, and the whole welded together. They are joined together, end to end, successively, by welding, thus forming a frustum of a hollow cone, the hollow being cylindrical. In giving form to the cone, in the press, its size is determined by a mould of great thickness and strength, which incloses the heated portion of the

cone, while a solid mandrel occupies the hollow cylinder, the fence being applied to setts upon its ends. The pores of the metal are therefore closed, and the metal condensed to a degree not to be obtained by the hammer. By turning and boring, this frustum of a cone is formed into the cannon, the breech being closed by a screw plug, and the trunnions fixed upon a band, which is likewise screwed upon the outside of the gun. The trunnion-band and trunnions are formed, like the cannon, by machinery moved by the hydrostatic press." That is a very accurate description of the process now carried on at Woolwich.

Sir William Armstrong: A very small resemblance, indeed.

Captain Blakely: At Woolwich, a screw is used to weld the short cylinders together, end to end, instead of a hydrostatic press, and the Woolwich guns are not lined with steel. Now, Mr. Treadwell's guns thus formed with steel lining stood very well, but Mr. Treadwell, thinking he could dispense with the steel altogether, formed some cannon of wrought iron, on the coiled principle, welded from end to end, and these utterly failed. I will read his words:—"During the trials of these guns at Fort Monroe, I was engaged in making the thirty-two pounders contracted for with the department of the Navy. These were finished in November 1844; and, although their weight was less than 1,900 pounds, the calibres being seventy inches long, one of them bore a succession of charges, commencing with eight pounds of powder and one of shot, and ending with twelve pounds of powder, five shot, and three wads. I ought to state, however, that in making some other guns of like size and kind, being unable to procure steel of proper quality for lining their bores, and misled by the extreme hardness of the small guns, I ventured to make them of iron throughout. The consequence has been, that, in two instances, guns similar to these made for the Navy in other respects, on being fired with very high charges, as sixteen pounds of powder, were enlarged by the ball making a lodgment of about $\frac{4}{100}$ths of an inch deep, and show a slight starting of the metal upon the external surface corresponding with the point of lodgment. The use of steel, however, is certain to obviate all imperfections of this kind hereafter." This, my Lord Duke, is evidently a faithful account of an experiment fairly conducted, and I think it should not be thrown aside as perfectly worthless.

Mr. Samuda: Yes, it ought; it has nothing to do with what we are making in the present day.

Captain Blakely: It shows if you are going to use a cast-iron bullet that the wrought iron will not stand it. Some time afterwards Mr. Treadwell in 1856 proposed another system of construction based upon an experiment which he formerly made, and upon other data. I wish to call your attention to the principle of the proposed construction:—"To obviate the great cause of weakness arising from the conditions before recited, and to obtain, as far as may be, the strength of wrought-iron instead of that of cast-iron for cannon, I propose the following mode of construction. I propose to form a body for the gun, containing the calibre and breech as now formed of cast-iron, but with walls of only about half the thickness of the diameter of the bore. Upon this body I place rings or hoops of wrought-iron, in one, two, or more layers. Every hoop is formed with a screw or thread upon its inside, to fit to a corresponding screw or thread formed upon the body of the gun first, and afterwards upon each layer that is embraced by another layer. These hoops are made a little, say $\frac{1}{1000}$th part of their diameters, less upon their insides than the parts that they enclose. They are then expanded by heat, and, being turned on to their places, suffered to cool, when they shrink and compress, first the body of the gun, and afterwards each successive layer, all that it encloses. This compression must be made such that, when the gun is subjected to the greatest force, the body of the gun and the several layers of rings will be distended to the fracturing at the same time, and thus all take a portion of the strain up to its bearing capacity." It thus appears that Mr. Treadwell, finding coiled-iron guns would not do, lined them with steel, and succeeded in making excellent 6½-inch guns; but that for larger sizes he afterwards recommended the plan I have now read.

A gentleman inquired whether any were made and tried on that system.

Captain Blakely: It is now used in America under the name of the Parrott Gun. The Parrott gun is a little thicker in the cast iron, which would perhaps weaken it rather more; but of all the Parrott guns which have been used in the present war in America only one has burst. The French tried precisely the same plan. Here is the figure of a French gun (Plate II. fig. 14); it is the same as the old 32-pounder gun; it has seven steel hoops upon it of about 2 inches in thickness, very carefully adjusted on the inside, and the consequence is, that guns of that description have frequently

been fired 2,000 times without destruction; and they are able to pierce the plates at 1,000 yards without any difficulty.

A gentleman asked what was the size of the plates.

Captain Blakely: 4½-inch plates. With 25 lbs. of powder they throw a 92-pound shot through 4½-inch plates, with 1-deg. elevation only, 1,000 yards. I have not seen them do it; but my authority is such that I cannot possibly doubt it. If any doubt is thrown upon the fact, I have here the official report of the Spanish gun (Plate II. fig. 15); they have tried the same gun; it is of very much less strength, as you perceive from the figure, than the French gun (fig. 16 is a section of the bore, and fig. 17 k, *l* are sections of the shell). The hooping extends a very short distance indeed, and yet with that Spanish gun they were able to fire 1,366 rounds with an average charge of 7 lbs. of powder and a 61 lb. projectile before the gun burst. The Ordnance Select Committee of Spain say in their report: "Although the 1,366 rounds fired with the above charge of powder and an elongated shot of 61 pounds are sufficient proof of the satisfactory resistance of the gun, the following observations will render still more apparent its excellence, and consequently that of the hooping system. During the first days of proof, 100 rounds were fired with intervals of only from one to one minute and a half. This made the gun so hot that it could not be touched with the hand. The following days 50 rounds were fired in the morning and 50 in the evening, with the same rapidity." With such rapid firing, I do not think any brass gun would have stood 100 rounds. But, supposing my argument to be entirely fallacious with respect to the necessity of hardness in the gun, still we must use cast iron, for the simple reason that we cannot get anything else.

General Anstruther: You can get cast brass.

Captain Blakely: I do not think brass has ever yet been cast the size I was about to say we must use, and that some of the American guns are being made now; they are making them of 17, 20, and 25 tons weight.

General Anstruther: Half that size of brass will do.

Captain Blakely: Therefore we have no choice, if it comes to huge guns. The late events in the mouth of the Mississippi river prove that it is not only necessary to have guns which will injure a ship, but guns that will stop a ship. We want a gun, from which one or two shots will stop a ship, and we want to place those guns in such a position that we are perfectly certain to hit the ships. I should prefer about 100 or 150 yards to 1,000, because the more one sees of artillery practice the more one would like to have the enemy pretty close. Should steel prove to be the best material, we shall find ourselves more limited, and more obliged to build the guns up because we are limited as to the amount of steel which we can get. We have no choice in the matter. We are obliged, by the necessities of the case, either to use cast iron, or to build up the guns in pieces, because we can only get pieces of a certain size.

Captain Fishbourne: Perhaps it is right I should answer one or two remarks which were made by my friend Colonel Lefroy. I can quite understand his being a little riled at my poaching upon his preserve, and his not adopting the recommendation which your Grace gave, that we should calmly talk over this subject. I am quite sure if he had calmly considered it he would not have said what he did. He has charged me with want of scientific accuracy in my comparison of point-blank ranges and different elevations. There is no doubt there is a great irregularity in the returns which come from his office, and they require a Philadelphian lawyer to discover what's what. I think I have distinctly stated to this audience what's what in these tables. I have explained distinctly where they come from, and I have explained what is the weight they are entitled to. There is no mistake with respect to the 68-pounder, and no mistake about those experiments at Portsmouth; they were all fired from a common platform. There is no difference in height of level there, and they are the results of the comparative penetration of those shots. I understand Colonel Lefroy to say, the guns will not stand if there is a reduction of windage. Now the windage of those guns is ·198, and they have stood that. It is a most difficult thing to give a relevant fact; it may be a fact in Colonel Lefroy's mind, but we want relevant facts; it is quite true if you put an undue tension upon an old 68-pounder, it will not stand; if you reduce its windage unduly it will burst; but the question is, Can you make a gun such as he is arguing for being made, built up if you please, or of wrought iron, that will stand it? I say, if Sir William Armstrong's gun will bear the enormous tension which he tells us it does, make them on the same principle, but let them be smooth bores, and let them have small windage; he says the guns will burst if they have small windage.

This which I have described as being ·233 in the 32-pounder (see Table D.) has been reduced by Monk to ·175, but we have got guns with less windage than that. Colonel Lefroy knows perfectly well that in the arsenal there are many guns which have the windage as low as ·120, and I believe even as low as ·1, very nearly one-half of that which I have described as the windage of the 68-pounder. But what is the fact with respect to the Armstrong gun, I mean the multigrooved gun? If there is no windage at all, either it has less tension, and does not bear the enormous strain he tells us it does, or else we can reduce the windage of our guns very materially. I do not profess to a great deal of scientific accuracy, but I do believe that I have taken pains, and that I am accurate as respects these statements.

On the motion of General Lindsay, seconded by General Boileau, the discussion was adjourned to the following evening.

ADJOURNED DISCUSSION.

Tuesday Evening, May 20th, 1862.

Colonel P. J. Yorke, F.R S., in the Chair.

Sir W. Armstrong, C.B.: Mr. Chairman and Gentlemen,—The chief argument adduced last evening by Captain Fishbourne, in support of his position that rifled guns were inferior to smooth-bores, was the alleged incapacity of the rifle to produce high initial velocities. This he attributed to the friction sustained by the cylindrical projectile in passing through the bore; but he adduced no experiment in support of that view. I, on the contrary, taking an opposite view, am enabled to refer to experiments which were made only last week, in which the rifled 12-pounder gun was loaded with a charge of one-fourth instead of one-eighth the weight of its projectile, the same in fact as the usual charge of the smooth-bore 68-pounder, and the result was that the initial velocity rose to 1,740 feet per second, being something more than the initial velocity of the round-shot gun; I can also appeal to experiments which have been made with lead-coated projectiles, having the lead considerably reduced in diameter, so as to facilitate the passage of the shot through the bore, and it was found that, instead of the reduced friction increasing the initial velocity, the result was rather the contrary.

Now, this is not at all difficult to understand, because you will easily see that by holding back the projectile until the powder is thoroughly converted into gas, that you will get a higher pressure upon the projectile, and impress a greater quantity of work upon it. But at the same time, those two facts of the greater initial velocity attained with the increased charge, and of the effect of diminishing the friction, put an end to the argument which was advanced last night by Captain Fishbourne, to the effect that the friction of the shot through the bore, was the cause of the loss of the velocity. Now, the fact is, the low velocity of a rifle projectile is due to a very simple and very intelligible cause. It is simply this, that the weight of the projectile is unusually large in relation to the charge. It is fired with one-eighth, instead of being fired with one-fourth, and of course it is perfectly natural that the velocity should be lost; in fact, the rifle projectile is generally equal in weight to about two spheres, and it is precisely equivalent to loading a smooth-bore gun with two shot instead of one. If Captain Fishbourne will try the experiment, he will find, if he double-shots his gun, notwithstanding the absence of that friction which he ascribes to the rifle-shot, the initial velocity of the two spherical shot will not be one atom greater than the initial velocity of the elongated shot of the rifle projectile. But although in the rifle projectile we get a smaller velocity, we, on the other hand, gain by the additional weight. The measure of the damaging effect of a shot is well known to be expressed by the square of the velocity multiplied by the weight; so that the energy or power of inflicting mischief in the case of a 68-pounder, which has an initial velocity of about 1,580 feet a second, would be expressed by 1,580 squared, multiplied by 68, the weight of the projectile. On the other hand, the energy or mechanical force of the rifled 110-pounder, would be expressed by 1,210, which, with the charge of 14lbs., is about its initial velocity; 1,210 squared, multiplied by the weight of the projectile, 110lbs. Those numbers work out rather large; but the result would be a proportion of about 17 to 16 in favour of the 68-pounder gun. That is at the muzzle of the gun; and this small difference, you observe, is not even proportioned to the difference in the charge; it has been clearly ascertained that, where the charge is increased, the effect is increased quite in the same proportion. Now I am

satisfied that the actual effects produced upon plates are in strict conformity to this rule, notwithstanding the representation of the effect which was expressed in Table A., in which the 110-pounder gun was shown to produce an effect expressed by 2·25, while the 68-pounder gun is represented by the very much larger number of 5·06. Now this is entirely contrary to the observed facts. I may also point out, that this amount of indentation expressed in that table, is not the usual indentation, by any means. The usual indentation of a 68-pounder shot is 1⅜ of an inch. Then, if we are to take particular instances, I know cases in which the actual effect produced by the 110-pounder exceeds the effect produced by the 68-pounder. There are at present standing at Shoeburyness, two targets, made upon the laminated principle, one of ten inches thick, and the other of six inches thick; and it is unquestionable that upon those targets the 110-pounder, at the distance of 200 yards, produced a greater effect than the 68-pounder. In fact, there can be no doubt whatever, that the general effects are very closely approximated to what the theory represents. Sometimes the effect may take the form of indentation, and sometimes it may take the form of fracture, or bulging, or breaking the bolts; but I believe, generally speaking, the effect of a heavy shot, fired with a reduced velocity, will be to produce extensive fracture, while the effect of a lighter shot, fired with a high velocity, will be more of a penetrative character.

Now, Captain Fishbourne ignored the very important consideration that the velocity of the round shot was rapidly diminished from the time of its leaving the mouth of the gun—that, at a very inconsiderable distance, it was reduced to an equality with the heavier rifled projectile. The fact is, that, at a distance of 670 yards, the velocity of the two projectiles is the same. Now, at that very inconsiderable distance therefore, we have in the heavier shot a power exceeding that of the 68-pounder in the proportion of their respective weights—that is to say, as 110 to 68; at the greater distance, that superiority is still more marked. But if the effect be so much greater at 670 yards, it may also be greater in a considerable degree at a much shorter distance; and I am perfectly satisfied that even at 350 or 400 yards—in fact, within the distance of what is usually termed point-blank range—the penetrative, the battering, destroying effect of the 110-pounder is greater than that of the 68-pounder.

Now, there is another consideration which has not been noticed, and which constitutes the most important recommendation of the rifled gun; and that is the power of its shell. The bursting charge of the shell of the 110-pounder gun is 8lbs. of powder, whereas the bursting charge of the 68-pounder spherical shot is only 2¼lbs. of powder. Now, this is a prodigious advantage. It certainly may be said that shells are of no avail against iron-plated ships; but, on the other hand, I may say that neither 68-pounder guns, nor 110-pounder guns, with solid round shot, are effective against such iron vessels. Therefore, we must compare such guns, not for services for which they are not suited, but for services for which they are suited; and for operating against timber ships, and for shelling forts and arsenals, and troops on shore, there can be no question whatever, that the 110-pounder rifled gun is immeasurably more effective than the 68-pounder—in range, in power of shell. It has enormously the advantage for battering purposes; for penetrating purposes it has also the advantage, except for a very short distance indeed; and, even at this short distance, it is very doubtful whether it has any very decided inferiority; at all events, no inferiority greater than would be made up by increasing the charge equal to the one-fourth of the 68-pounder.

The fact is, what we want is a gun, in addition to our 110-pounder rifled gun, especially adapted for breaking through iron plates. That is what we really are in want of now; and that is what the discussion of this meeting ought to turn upon—whether that gun ought to be a rifled gun, or ought to be a smooth-bore gun.

Now, in entering upon that question, we are at once met with the very important consideration, which has not as yet received any attention, and that is the weight of such a gun, and the practicability of carrying it on board ship. It seems clear, now, that, to produce decided effect against iron-plated ships, it is absolutely necessary to use very heavy charges of powder—how heavy is not yet very distinctly ascertained; but certainly there is little prospect of producing any sufficient action with less than 35lbs. of powder. Now the question is, what will be the weight of gun capable of bearing 35lbs. of powder? If we make that a cast-iron gun, and if we make it in proportion to the 68-pounder—95cwt., which fires 16lbs. of powder—we should have to make it a gun of about 10½ tons; but if we make it of wrought iron, and upon the coil system—which, I contend, affords the greatest strength for a given weight of material of any method which is now in use—I anticipate that we should be able to reduce that

weight to about six tons, or something under. This, however, is for a smooth-bore. If we make the gun a rifled gun, then I do not think it will be prudent, if we are to use it with a charge of 35lbs. of powder, to go below eight tons. Although I fully admit and contend that the rifle has immense advantages over the smooth-bore, the question is, whether the navy can afford to carry that additional weight for the sake of obtaining the advantages of rifling.

Now this question requires to be considered under two aspects: first, as regards present ships, and, secondly, as regards future ships. As regards present ships, naval men seem to be agreed that it is not possible to carry broadside guns much heavier than the present 68-pounder; or, at the very most, that six tons must be the limit.

It is a nautical question purely; and therefore I cannot venture to give an opinion: I can only adopt their dicta upon the subject, and, assuming them to be correct, I do not see what alternative we have, but to make that gun a smooth bore, in order to keep it within the weight. It is, therefore, as a matter of necessity, not as a matter of choice, that I think this particular gun ought to be made a smooth-bore. As regards future ships, the case may be different, because I believe the advantage of heavy guns on the rifled principle will in future be so fully recognised, that the construction of ships will be made to bend to the necessities of the case, and to carry guns of a much heavier calibre, and that those guns will be rifled.

I will now endeavour to explain why it is that a rifled gun must be heavier than a smooth-bore, and, for this purpose, I will direct your attention to the longitudinal diagram which I have drawn (see Plate I. fig. 11), showing the bore of a gun of 9½ inches in diameter, with a cartridge containing 35 lbs. of powder, and measuring in length 17 inches, and having a round shot placed before it weighing 100 lbs. Now, if I were to rifle that same gun, and substitute for the round shot a rifled shot of twice the weight, then it must be clear that the powder having a greater mass to move, the gas will meet with a greater resistance, and will get up a greater pressure behind the shot, and it will be necessary to add additional strength to resist that extra strain upon the gun. But it may be said that we cannot oppose a greater resistance to the shot, and thereby get up a greater pressure, without impressing upon the shot a greater amount of work, and this I am quite prepared to admit. I believe that, if the bores be the same, that if the powder can expand to the same limit before it escapes into the air, there is a greater quantity of work—a greater power of inflicting damage—resident in the heavier rifled projectile than in the lighter 100-lb. shot. But it is, nevertheless, equally necessary that we should add strength to that gun, and, in adding strength, we must necessarily add weight in larger proportion, because we can only add the material to the exterior of the gun, and every additional layer that we apply being of a larger circumference, involves an additional weight more than proportionate to the increase of strength; therefore it is that, in making that gun of sufficient strength, we make it heavier than is equivalent to its greater strength.

But it may be said, why not keep the weight of the shot the same, and reduce the bore, so as to enable the same proportions to be retained. Now, we will try that alternative; and here we have it represented. I have in this case taken the bore at 7½ inches, which, I believe, is approximately correct for a round shot of 50 lbs. (See fig. 12.) In this case, by making the projectile of the same proportion as in the other case, we make its weight 100lbs., or the same as the sphere in the other case. Now, to apply the same cartridge—the same quantity of powder—because that is the condition,—the area of the bore being only one-half what it was before, it is necessary to make the cartridge twice the length, as represented here. Hence, therefore, although the circumferential area exposed to the pressure of the powder is diminished in the proportion of 7½ to 9½, yet the longitudinal surface is increased in the proportion of two to one; and, consequently, we have a far greater surface exposed to the pressure of the gas at the first instant of ignition in the one case than we have in the other. The strength of the gun must therefore be continued further forward. But not only that, after the shot of the smaller bore has travelled through once the length of its cartridge, the length of bore filled by the gas will be twice 34 inches, or 68 inches; whereas, when the other has travelled through once the length of the cartridge, so as to give double capacity for the powder behind, it will only have travelled 34 inches; and therefore we must bring forward the corresponding strength of the gun in the one case to 68 inches, and only to 34 inches in the other case. It is clear, therefore, that we gain nothing by reducing the bore, but rather the contrary.

Then there is another consideration. In order to get the same duty out of the gas produced by the powder, we must afford it the same number of expansions. Suppose the barrel to be seven times the length of the cartridge, which would make it at 119 inches. In that case we get in the larger bore seven expansions of the gas, and then, at the end of that, it escapes into the atmosphere. But, supposing we make the other only the same length, we shall then only get three-and-a-half expansions; and, consequently, we do not get the same duty out of the powder. It is necessary, therefore, with the small-bore gun, in order to make it equally efficacious in that respect, to double the length of the barrel; therefore we must either sacrifice efficiency, or we must make the gun inordinately long and inordinately heavy. Now, if we could make a rifle shot of the same weight as the sphere, then we should avoid this difficulty. But, if we do so, we, in point of fact, gain very little advantage over the round shot. It is only by the elongation of the projectile that we gain the advantages which are due to rifling.

Another alternative is to rifle the gun, and to use the high charge only with the round shot. It is most important to preserve the advantage which the rifling gives in regard to shell, for which a reduced charge might be used: that is to say, we should have it as a rifled gun fired with a lower charge, and as a smooth-bore gun with a higher charge. The only question relating to this is the practicability of using round shot with a grooved gun. There is much to apprehend on that ground, because, even without any grooves at all, we find, by using these extremely heavy charges there is a tendency to indent the gun; and any system of grooving would materially increase that tendency. It remains to be proved, however, whether by using *sabots*, that can be obviated. If it could, it would probably be the best way out of the difficulty to have your gun only sufficiently strong and only sufficiently heavy to be enabled to use it with the full charge, as a round-shot gun, and to use it for throwing shells of greater weight and large capacity with a reduced charge.

Captain Fishbourne adverted to a few additional topics, which I think I may very quickly pass over, as I feel I have already occupied much of your time. In the first place, he represented the trajectory of the 68-pounder round shot, as greatly superior at small elevations to the trajectory of the 110-pounder shot. There is a diagram here (Plate I. fig. 13), which shows the effect of a shot from a trajectory passing high over the top of a ship, while another either strikes the ship, or is very close upon it. Now, clearly, this is a very distinct way of showing the effect; but it must not be supposed that these are the correct delineations of the two trajectories. The difference between the trajectory of the 110-pounder and the 68-pounder, even at very low angles, is exceedingly small—very small indeed—nothing to be compared to what it is represented here; and at longer ranges the difference is greater in favour of the rifled gun.

Another point which Captain Fishbourne took was the straightness of the ricochet obtained by the round-shot gun. No doubt upon perfectly smooth water, the round shot does ricochet straighter than the rifled shot, although when the angle is very low, even the rifle shot ricochet very straight. But upon an undulating surface, such as you must almost invariably have at sea, the ricochet, whether it be with the round shot or with the rifled shot, is exceedingly wild; therefore I do not think that amounts to very much.

Captain Fishbourne criticised the coil system of construction. He referred to a diagram (Plate I. fig. 2), and pointed out various overlappings. He stated that it must necessarily happen that it would draw asunder, and disintegrate in places, and so on. However, all that is met by the fact that it does not take place; and I think I need not argue the question further.

Well, he objects to breech-loaders. All I say is, that breech-loading has its advantages. The most conspicuous of those advantages are, that you are enabled to use a long powerful gun in ships of small beam. If you use muzzle-loaders you must run them in-board, and to do that you require a great breadth of beam; consequently the armament of narrow ships is limited to short guns. In addition to that, you expose your men at the ports.

I think the only additional point I need advert to is, that Captain Fishbourne attaches great importance to a diminution of windage in the round-shot gun, and he produces here a table (see Table E), the correctness of which, although he produces his authority, is glaringly wrong. Here is a difference of windage! There is ·025 in that case; and here you will see ·170; a difference of windage, which is scarcely more than we have in our 32-pounders: the range in one case is represented as 288 yards, and in

the other as 52 yards. Everybody that is in the least degree conversant with these matters knows that that cannot be.

I do not know that I have anything more to say, unless it be to recapitulate that my views are all in favour of rifled ordnance. I am perfectly satisfied that the future gun of the navy will be a rifled gun. But, taking things as they are, and looking to the necessity of accommodating weights and so forth to existing ships, I think there is a strong case made out for the use of smooth-bores as broadside guns, for the special purpose of grappling with iron-plated ships.

The CHAIRMAN: Will you allow me to ask, Sir William Armstrong, whether you think there will be little difficulty in making rifles to bear charges of the proportion of one-fourth instead of one-eighth the weight of the projectile?

Sir WILLIAM ARMSTRONG: I think there will be great difficulty. It is only necessary to look to that diagram (Plate I. figs. 11, 12), and see what cartridges you would require. In one case you would require a cartridge twice the length of the other.

Admiral Sir FREDERICK GREY: I should like to ask one question. Would there be any difficulty in coating a spherical shot with lead, the same as an elongated shot, so as to use it without any danger to the bore?

Sir WM. ARMSTRONG: There would be no difficulty in attaching zinc solder, by Mr. Bashley Britten's plan; but I do not very clearly see the object that would be attained by it.

Sir FREDERICK GREY: I was alluding to what you said in reference to using the spherical shot or the elongated shell.

Sir WM. ARMSTRONG: To avoid indentation?

Sir FREDERICK GREY: To avoid injury to the rifling: whether you could not avoid injury to the rifling with a spherical shot?

Sir WM. ARMSTRONG: Oh, yes; it is quite feasible to coat the round shot.

Colonel WILFORD: If I may be permitted, I should like to ask Sir Wm. Armstrong a question. I beg to ask if he has directed his attention to the effect of the recoil in heavy guns, with a charge of 35lbs. of powder? The present 68-pounder is rather a lively gun when it is fired. Even now the recoil is in the proportion of 1 to 32. Therefore it strikes my mind, as a practical man, the difficulty might arise in managing the recoil of so light a gun with so heavy a shot and so powerful a charge.

Sir WM. ARMSTRONG: I have considered that subject a good deal; and I have certainly arrived at the conclusion that, by a proper system of compressors, you can control the recoil. I do not think it will be easy to reduce the weight below that limit; but that, again, constitutes one of the difficulties of using rifled guns with those high charges and heavy shot, because the recoil is much more affected by weight of shot than by velocity. The work impressed upon the shot, is in the ratio of the square of the velocity multiplied into the weight; but the recoil of the gun is in the direct proportion of the weight of the shot, and not of the velocity; and, therefore, the recoil would be more severe in the rifled gun than it would be in the other. And, consequently, that is an additional reason for adding to the weight of the rifled gun.

Colonel WILFORD: The necessity, in fact?

Sir WM. ARMSTRONG: Yes.

Mr. CHARLES LANCASTER: The question that has been so ably brought before the notice of the meeting by Captain Fishbourne, is without doubt one of very great importance, and to it, I am sure, the energies of the mental powers of the many distinguished gentlemen round the room will be devoted with much anxiety. On the last occasion our noble Chairman alluded to a state of doubt and uncertainty, which those in power and the profession generally felt in reference to the great question of the rifle gun for the service; and he alluded in terse and proper terms to the question as to whether it should be of cast iron or of wrought iron, or whether a compound of both cast and wrought iron. It was a question on which he expressed doubt and uncertainty, and one that required elimination and careful argument, in order that the true principles upon which our naval gun should be constructed might be placed in an intelligible and proper form, for the determination of those who hold authority in the country. With that view, perhaps, it may be as well if I endeavour to take the matter up, and to express, as far as in me lies, my humble opinion as to the merits of the various methods of constructing naval guns, and perhaps to show some few points about it, to the notice of the meeting.

First and foremost, I think it can be scarcely questioned or denied, and least of all will I attempt to question or deny, that to the distinguished director of rifled

ordnance, Sir William Armstrong, we owe very much, for the very admirable and perfect specimen of a wrought-iron gun he has presented to the British public. As far as regards the question of muzzle-loaders, I think it may be held as decided, that a gun of surpassing strength and wonderful mechanical execution has been produced by that gentleman, and to him we owe much. The question of the superiority of wrought iron guns for field purposes, I think, can scarcely admit of a doubt. The superior lightness which it is possible to give to these guns affords very great and grave arguments in their favour. I am not now, gentlemen, touching upon the question of breech-loaders at all, but merely upon the question of the use of wrought-iron for the purposes of artillery. In naval guns another question comes into play, which was very properly touched upon by Sir William, and that is, the weight of the guns. Now, when wrought-iron guns were first manufactured for the purpose of naval guns, I think it will be within the remembrance of many of the gentlemen who surround me, that it was proposed to make those guns very considerably lighter than the proportion heretofore held as desirable in reference to cast-iron guns. The proportion of the cast-iron 95-cwt. gun, of which so much has been said, is something in the ratio of 156·5 to 1, to the unit of the projectile, and the wrought-iron gun first introduced as a naval gun was very little more than half of that ratio in proportion to the unit of the projectile; therefore of necessity limiting the initial velocity that can by any possibility be given to the projectile, having regard to the proper conservation of the carriages. Gradually, as experience has progressed, the weight of the wrought iron has steadily gone up; that which was 65 cwt. is now 85 cwt., and perhaps it will be found desirable to make it more; therefore, we come to the very tangible proposition: a given weight being absolutely necessary where a given weight of projectile is to be projected with a high velocity, are we to be confined to wrought iron? Is it true that wrought iron is the only material? Is it true that a very beautiful mechanical specimen of engineering, to be produced at a very large price, is the only material, or is it possible, by some other adaptation of, or combination of, other materials, to yield an equivalent result—bearing in mind you have to deal with a certain fixed weight, below which you cannot go? Assuming that proposition to be a somewhat intelligible proposition, and bearing in mind that one important point in reference to the present construction of wrought-iron guns has not been touched upon, and that is this, that they must be not only fired from, but fired at, in actual warfare, I think that that must not be lost sight of in taking into consideration the construction of the present wrought-iron gun. Guns will sometimes be hit, you know, gentlemen, in action; and if guns are hit on the muzzle that are rather thin and built-up with several layers, they are open perhaps to grave objections, which I need not explain to practical men. But it is practically obvious that wrought iron will indent, and that, being indented, if it were a muzzle-loading gun you could not load the gun again. I mean, supposing a three-pound grape shot at 100 yards, such as is used in a naval action, struck it, it would be a serious question whether the gun would not be subject to rupture. Now, cast-iron does not indent in that way. You will see in the Arsenal at Woolwich several guns that have suffered very severely at Sebastopol, from being struck at the muzzle, and have been fired very repeatedly afterwards, and are still fit to do a little more service, although they are of cast iron. Therefore, I say, without condemning the use of wrought iron, and without at all interfering or wishing to detract from the value of wrought iron as the means of securing an enormous amount of endurance in a naval gun, that it is worth while to consider, to pause, to deliberate, and see whether there is not some hope of being able to render cast iron a still available agent for naval purposes at the present day, when high velocities are so exceedingly essential, when the cast iron is fortified by a proper application of wrought iron on its exterior surface. With that view, with your permission, gentlemen, I will, with the aid of the many diagrams here, endeavour to point out what has taken place in reference to this question of the possibility of strengthening cast-iron guns, hoping that what I may have to say, may elicit some discussion, some expressions from the many distinguished officers round the chair, and that it may assist the authorities in arriving at a tangible decision in regard to the matter.

Early in October, 1859, I had the honour of submitting to the Secretary of State for War a proposition in reference to the strengthening of cast-iron guns that appeared to bear some new and peculiar features. As you see round the theatre, gentlemen, there are many specimens of various methods of strengthening cast-iron guns, some in use by the Spaniards, some by the French, and others that have been tried in various forms under the superintendence of that very able body of distinguished officers with

whom I have been in contact for so many years, the Ordnance Select Committee at Woolwich, and who have given much time, great attention, and their most earnest endeavours to the elimination of this matter. The cast-iron gun, I need not observe, has been the subject of many experiments in regard to the possibility of strengthening the cast iron by placing on its periphery wrought-iron, in the shape of rings of various thicknesses and various forms. A distinguished American gentleman, mentioned by Captain Blakely, Mr. Treadwell, and Captain Blakely, Mr. Hughes, and many other gentlemen, have devoted much care, time, and attention to the matter, and from time to time many experiments have taken place at Woolwich, and, I believe, in the course of the experiments, some 10,000*l.* of public money was expended to see if it was possible to produce a strengthened cast-iron gun. But until October, 1859, the whole of those experiments went to this fact, that the gun was turned more or less cylindrical on its exterior surface, and hoops, more or less thick, of wrought iron, were carefully bored, heated, and shrunk on to the exterior of the gun, but without any regard—I beg you will bear with me in this particular—to the longitudinal strain that results to the gun upon the combustion of the powder; that is, the powder acting in all directions alike, acting on the rear end of the gun as well as on the side of the gun. If you leave the end of the gun in its normal state, and merely depend on the tensile strength of so many inches of cast-iron, of course it is no use strengthening it on the periphery of the gun, and that gun will burst as nearly as possible in the same time as if it were wholly of cast iron. That was the result of these experiments, and so much so, that, in the results at the proof-butt at Woolwich Arsenal, guns burst after 51 rounds of destructive proof.

Now the propositions brought to the notice of the Select Committee on that occasion embraced another principle. Is it not possible, the normal end of the gun being in the normal condition of cast-iron, deficient in tensile strength, by enveloping the breech end of the gun in some degree, so to brace and truss the gun together, that it will sustain a very much more severe proof? Efforts were made in that direction, and a gun was prepared in which the rear end of the gun was turned down over an inch and a half on the posterior quarter, and a longitudinal truss was fitted on over it, in this way enveloping the ends an inch and a half, and completely embracing the gun; the wrought-iron hoops being then shrunk on over the longitudinal truss. A very remarkable result was given by this experiment. The gun immediately went up in scale of strength under the same condition of ten pounds of powder, the unit of projectile of a 32-pounder, and so on, increasing every ten rounds one unit; it went up to 81 rounds instead of 51. I confess to be a believer in figures; if mathematical formula mean anything, and if supporting the periphery of the gun for 1½ inches does really give, which this gun really did give, 31 rounds of destructive proof, plus any other; then, if you believe Hart's formula, I think you will find that if the whole rear end of the gun could be cut off, and if, instead of merely supporting the rear end of the gun for 1½ inch longitudinally, you support the whole of the rear end of the gun by a solid case of wrought iron, and transfer the longitudinal or tensile strain on to the wrought-iron jacket, you have done a great thing. (See Plate I. fig. 5.) I believe you will get from a cast-iron gun strengthened in that way, everything that you can get from a gun for the naval service. That is my impression; I may be in error; I think there is reason on the side of the proposition. It was argued carefully before the Select Committee of Woolwich; they gave it their most serious deliberation, and we have reason to believe that they thought that, considering the fact that £10,000 had already been expended on experiments, and as the proposition itself was novel and promised great results, it was desirable that it should be tried. I have reason to believe it was so reported by those gentlemen, and I gravely regret it was not thought desirable to try it by those who held the higher authority—of course for the best possible reasons which I cannot enter into now. The proposition, as it now stands, is a proposition that holds out every probability of success, as far as it is possible, by mathematical deduction, to assign a reason and a cause. I believe that it would be successful; but still it has been deemed not proper to try it, and so it has not been tried. That is precisely the condition at the present moment. I wish it were to be decided otherwise, and I hope yet to see, for the interests of science, and for the definitive settlement of a question of so much interest, that point, which I still hold to be very interesting indeed, should be tested in a proper way by the proper authorities.

Having so far brought to your notice the different points that occurred with reference to the strengthening of cast-iron ordnance, I will now pass on by a sort of transition to

our old friend the cast-iron ordnance. And I wish to mention that subject in order to elucidate and bring before your notice some very interesting trials that were commanded by the late lamented Lord Herbert. That was the question of the proper mode of rifling the cast-iron gun of the service. We know that, as far as regards timber vessels, the cast-iron gun of the service was capable of rendering, when rifled, or even unrifled, very great and efficient service in the defence of the country, and it was thought at the time, that if it were possible to determine once and for ever whether the gun would bear the process of rifling, beyond question and beyond cavil it would be information to the authorities ; and at any rate it would determine what method or system of rifling, whether applied to cast or wrought iron, would give the most satisfactory results under all the contingencies of the service. With that view, some seven or eight gentlemen—the names are all placed here—were called upon by the War Department to contribute their plans and give their advice, and to state their reasons, and to give their opinions, as to the best methods of cutting the interior form of the cast-iron service gun in the most advantageous way, in their impression, for the public service. Now, those trials are nearly completed, I may say concluded. I do not wish, it would ill become me, to criticise the plans of so many gentlemen who have devoted their time and attention, and who, doubtless, are of opinion that their plans are preferable to others. I do not propose to criticise the various forms of groove, but merely to give the results as they have occurred as a fact. I have no doubt that many gentlemen will follow me who will advocate their own particular form, and will give good reasons for your consideration ; but, having to deal only with the facts of the matter and the results of the trial, I think it is a course open to no cavil, and will simply be for the information of the meeting.

The figures on these diagrams are all strictly correct, giving the weight of the shell, the number of grooves, the turn of rifling, the weight of the powder employed—every particular. I will not pledge myself to precise accuracy ; there may be some trifling decimal as to the depth of the particular scale to which they are drawn ; but still, for all tangible purposes, the shape of the groove, the length of the projectile, are preserved with fidelity. Some are lead-covered projectiles, some with the zinc represent Sir William Armstrong's shunt plan, some are grooves with iron fitted into them, and others have no grooves or anything of the kind. Now, it appears, without specifically relating which particular plan may be referred to, that some four or five guns on particular plans had a tendency to burst, and do invariably burst before the 50th round, some invariably burst before the 20th round, some went on to the 300th round and burst, and others now stand having fired 1,000 rounds, and are still in a perfect condition. Therefore, without particularising, or without adverting to the particular plans that have stood 1,000 rounds, or that burst at the 300 rounds, I think it may be taken as a datum that cannot be disputed, that if, with a certain standard of value which we may term the 32-pounder gun, it is proved that not merely one or two, but three, four, and five guns of a particular description burst before the 50th round, and that some three or four rounds of a particular description burst under 200 rounds, and that of another description two guns burst at 300 rounds ; and on the other hand, that guns of a particular description stand 1,000 rounds, there is good ground for those who have the direction of these matters to say, and reason very fairly by analogy, that, whatever may be the reason, this particular form of grooving or rifling has yielded a more satisfactory result, inasmuch as the guns have resisted to a much greater extent than the others. I think it is a sound ground to go upon, and it is also clear and incontestable that if you admit the premises in reference to the cast-iron gun it cannot be denied that the same rule is applicable in reference to the wrought iron, that if you say you have a better result with the cast-iron that it will be also led to apply to the wrought iron. But I may be permitted to mention this, that a most remarkable fact has come out in these experiments, and that is this, that in reference to the lead-coated projectile, if it is put on evenly as in some projectiles in a thin form, and you pass one-eighth of the weight of projectile as a charge, the lead is given off from the projectile on the discharge of the gun in the shape of an amber-coloured cloud, called lead fumes. I purposed showing the experiment, but, unfortunately, my apparatus became broken ; but if you throw lead in a finely-divided form upon an intense flame it is given off in fumes at once. It will be a pretty experiment for a lecture-table, but still it has been so often witnessed by gentlemen who have seen the lead projectiles fired, that it is scarcely worth while repeating it before the professional part of the audience ; and, furthermore, it is known that, if you exceed a charge of one-eighth, and go to the charge of one-fourth, you are then

exposed to another source of inconvenience, the positive melting and remaining of the lead in the bore of the gun ; that is the result of the experiment at Shoeburyness alluded to by Col. Lefroy. If, on the other hand, the lead is put on thickly and mechanically, as in another description of projectile, and you go beyond the tenth of weight in the charge of powder, as is proved by a great number of elaborate and practical experiments at Shoeburyness, the cast-iron gun bursts; that is absolute, there is no escape from it, because it applies to all modes of rifling in which the lead-coated projectile is used. If, on the other hand, you fit into a groove, of whatever form you like, an iron contour on the outside of the shell, or this kind of thing, or anything of that kind (pointing), after a certain number of rounds the edges of the grooves crush, and immediately on the crushing of the edge of the grooves, the bursting of the gun follows as matter of course. So that these experiments with the experimental rifled gun have yielded, I believe, to those who have the direction of all matters concerning artillery, very important, and, I believe, very valuable results.

The question of initial velocity has been more than once alluded to, especially by Capt. Fishbourne and by Sir William Armstrong. Now Capt. Fishbourne, I believe, held that it was impossible to obtain sufficient initial velocity, if I understood him correctly—I hope he will correct me if I make any error—with the rifle projectile; and he grounded his preference of the round shot, or the old service ammunition, in comparison with the elongated projectile, to its very greatly increased initial velocity in comparison with the rifled gun at present in use. Now, while admitting the value of the high initial velocity of the 95-cwt. 68-pounder gun, I must submit, with all deference to Capt. Fishbourne, that it is not at all proved, and never has been tried to the present moment—until Sir William Armstrong mentioned that a 9-pounder gun fired a few experimental shots at Shoeburyness the other day with a quarter charge—that the rifled gun had ever been tried with approximate charges of powder in comparison with the service 68-pounder gun. Now it is not at all clear that it cannot be done. I am of opinion that it can be done ; in fact, I have been for months endeavouring to impress this matter upon the attention of the authorities ; and so far back as the 13th of March, 1862, I had the honour of addressing a letter to the Select Committee on this very subject. It might be too long to read, I won't trouble you with it, but the main point is this : enunciating that the rifled guns had never been tried upon equal terms with the service gun, or what is known as the service gun, that they had never been tested with high initial velocity, and briefly suggesting the method by which guns could be constructed and tried, having the rifle motion communicated to the projectile, using one fourth of the weight of powder of that projectile, and having an initial velocity, as I said in my paper, of 1,650 feet per second, I firmly believe that with the advantage which up to the present moment has incontestably been held at certain ranges by the service or round shot, would be found to vanish completely if tested against rifled shots with high initial velocity, at the same distances. I can firmly believe that it is perfectly possible, and in fact I may say that to my knowledge it has been done, and I have communicated that knowledge to the War Department. It has already been done with rifled projectiles capable of punching through the thickest plate known in modern warfare—it is a misnomer to say modern warfare—but for the purpose of defending iron ships they have already been punched and perforated by elongated rifled projectiles at high velocity. I have by letter communicated that to the War Department, and offered to place drawings at their disposal. It is needless to say more upon that point. In reference to this paper of the 13th of March, 1862, I believe it will be recognized by those who have authority, that it was one of the first recognitions of the important point of communicating to rifled projectiles a high initial velocity, and I do not doubt that when it is fairly tried, not only will it give results that will surprise the profession, but I do not doubt that the very elaborate experiments of the Iron Plate Committee will have to be gone over again, and I hope, with results that will afford great benefit to those who have the charge of the construction of our ships, and no doubt afford a mass of information to the profession, and amply reward those entrusted with the onerous duty of testing those experiments again. I had the honour of laying before the Select Committee, plans for the brass gun of the service—converting it into a rifled gun—which embraced a distinct proposition, and stated that it was not necessary to have a large amount of ovality, but that the ovality would be something like what it is in the 9-pounder gun, not quite one-tenth of an inch, and such an arrangement made, without the use of lead upon the shot, that upon the explosion of the powder the projectile would conform to the bore, and receive the rifle motion with perfect facility.

I regret that it was not thought necessary to try it at the time, but it is one of those propositions that will come round in time, and I have no doubt will be tried hereafter.

Without detaining you longer, permit me to make one observation. Reference has been made both by the noble chairman and by Sir William Armstrong to the question of breech-loaders. It is a moot question whether the gun for the naval service should be a breech or muzzle loader. I confess I am not satisfied that the finality of breech-loading ordnance has yet been arrived at. I believe Sir William also expressed himself to that effect to the civil engineers, when on a late occasion he addressed them, that in reference to the heavy ordnance, he was also of opinion that further experiments were necessary, and he, in a most philosophical and admirable manner, explained to the meeting some further experiments he was carrying out for the benefit of the country. Bearing in mind that the observations I or any other gentleman may make, are solely for the benefit of the service, I may perhaps be permitted to explain to the meeting a very admirable plan; it is not my invention, but I believe it holds out great promise and is deserving of the very gravest consideration, and I am sure the great talent of Sir William Armstrong could not be better developed than by testing the thing in that fair and equitable way, that I am sure he will feel a pleasure to do when it is brought before him. Some four or five years ago I had the honour of bringing it before the Select Committee, and through the courtesy of Mr. Clay I had an opportunity of bringing to the door of this Institution a gun made somewhat on this plan, but unfortunately its weight precluded the possibility of introducing it into the theatre, so that I very much regret I cannot have the opportunity of showing the actual gun itself to the assembly. Still, if you will bear with me one moment I think this will sufficiently elucidate the matter and bring its prominent features to the notice of the assembly. I must premise by saying I have no doubt you remember the statement in the various papers that a wonderful breech-loading gun had been tried in France, that it was carried wonderfully swathed up and hidden, great secresy observed, and no one knew what it was. I am informed, and have every reason to believe it to be perfectly true, that the breech-loading gun tried on board the "Gloire" is substantially on this plan, and that the success that it has met with before the French authorities is such, that my impression is that it is well worthy of a trial and active consideration at the hands of our authorities. The breech-closer is simple, and, without criticizing that, or saying one word in reference to the many plans of breech-loaders that have been brought before the authorities, I believe it may be held as a definition that a breech-loader for artillery purposes is perfect in proportion to its simplicity. Now simplicity, I believe, may be defined as meaning fewness of parts; therefore, to hold to the definition as correctly as possible, if you have a gun which consists merely of two parts, the barrel proper and the closing screw, I think it must be held as an advantage over another kind of breech-loader consisting of more parts. I may be in error, but that is my impression. Now, you will perceive that the circle represents the cylindrical portion or bore of the gun; that of course may be rifled in any form, or non-rifled, as it may be required; and the posterior portion of this gun is so arranged that the closing screw which is represented here is not in an axial line with the bore of the piece. Consequently the screw itself may be termed as excentric to the bore. It is therefore obvious that when you wish to load the gun you have merely to give the handle a half-turn, and the hole which perforates the breech-screw, which is of a very massive kind indeed, is brought precisely in a line with the axis of the piece. You then insert your charges—there are easy means of regulating your charge so that it cannot work too far—that is very easily done, and with one half-turn of the screw the gun is thoroughly closed, and the resistance opposed to the charge is of course very enormous, because the screw is very great indeed, very thick and very solid, and not liable to be broken or cracked by the discharge of the powder. It occurs to me it is well worthy of the serious consideration of those who have authority in these matters, and with that view I thought it would be interesting to the meeting to bring a matter in which I have not the slightest interest before you for their consideration.

I have somewhat overstepped the time. If I have said anything that may at all elucidate the question of naval guns, it will have afforded me the greatest possible pleasure. And, in conclusion, I may state this, that I do believe, that, for a naval gun, it is of the highest importance to have a gun of large calibre and heavy projectiles, and a proportion of powder not less than one fourth of the weight of that projectile, let it be rifled or not. And, in reference to the question as to the possibility of shooting the ordinary service shot from a rifled gun, I think that may be disposed of in two words.

The Lancaster gun tried in the Crimea not only fired elongated projectiles but the service projectile, and it is on official record that many of those guns before Sebastopol fired as many as between 2,000 and 3,000 rounds of the service projectile; they have been brought home to England, and are still, some of them. as far as the bore is concerned, in an efficient state, and that there is no difficulty whatever, and it is so reported by the Select Committee of the period, in firing round projectiles from the oval-bore gun, and that the accuracy and range of the round projectile when fired from a gun so bored is as great and as accurate as the service gun fired in the usual way.

Colonel WILFORD: Although I must despair of saying anything equal in interest to that delivered by Sir William Armstrong and my friend Mr. Lancaster, I hope I shall compensate for it by my brevity. I may say, incidentally, having had the honour some years ago of belonging to what was called the Lancaster Committee on Mr. Lancaster's gun, that, in conjunction with Sir Thomas Maitland, I directed one of the experiments just alluded to. His gun, although rifled on the oval bore, to our apprehension threw round shot quite as well as the ordinary bore. I merely mention that, as I happen to be cognisant of the fact. I wish to say a word or two about cast-iron. What Mr. Lancaster said is perfectly correct, and I may state, on the authority of Sir Richard Dacres, who commanded the artillery in the Crimea, that some 68-pounders having been lent to the French, they endured 2,000 rounds. We also know that at the siege of San Sebastian our iron guns stood 300 rounds a day of full breaching charge. It was by means of these iron guns, the French using brass, that the Duke of Wellington was enabled to open his breaches sooner than was expected, and before the French could relieve the place. It could not have been done but by the use of iron. Every one is cognisant of the bursting of the mortar at Sveaborg. In a very learned and elaborate lecture delivered in this Theatre it was endeavoured to be established that the failure was due to the form of construction. It was shown there were certain lines of fracture, by certain laws of crystallography, where the fracture must necessarily take place. But other mortars were made on these same lines, and they stood 2,000 rounds fired quickly with 20 lbs. of power, showing that the form of the gun is mere moonshine compared with the quality of the metal. It is clear, then, that cast-iron will do the work if you can get it. But there the difficulty arises; you cannot get it. I believe a combination of so many circumstances is required—fine metal, great heat, and so on—that no ironfounder would undertake to produce two pieces alike. Therefore, I think we must come to the same form of wrought iron—either on the coil system, which I believe is the most satisfactory, or on some other mode. Allusions have been repeatedly made to the charge of one-fourth. That is one-fourth the weight of the shot. It may appear to the audience that that is the normal charge. But it is by no means so, for heavy battery guns. Before our powder was improved the charge for our guns in the navy 80 years ago, was one-half the weight of the shot. But our powder being very much improved, it was thought safe to reduce it to one-third. The French very recently, if not now, with their land service of brass guns, not being able to trust their cast-iron, fired with one-half the weight of the shot.

A VOICE: They do still.

Colonel WILFORD: They do still. Therefore, in order to get the best effects, we are not at all necessarily confined, if we have a gun strong enough, to a charge of one-fourth the weight of the shot. The reason why a 68-pounder is confined to a one-fourth charge, is, because the navy make a great objection to weight. I was at a joint Committee of Artillery and Naval Officers, when we proposed to have heavier guns. "Here," we said, "is your 68-pounder, which only weighs 95 cwt.; you can only fire with one-fourth the weight of shot." They said, "We cannot work anything heavier satisfactorily on our decks." That was conclusive. We know that Captain Dahlgren has introduced guns of 7½ tons—the 11-inch gun—showing that guns of great weight can be used. Something was said about penetration being as the square of the velocity. That is to say, with a double velocity you have four times the penetration; and with a treble velocity nine times the penetration. That, then, is the direction to go in, to have the best gun we can get for naval service which can be fired with at least one-third the weight of the shot, I should say three-eighths.

Mr. HADDAN: Instead of expressing any opinion, I wish to state what has lately been done. Two years ago, when Captain Blakely read a paper here, I expressed an opinion that hooped cast-iron guns would not succeed, and I think I am in a position to state, from what has been done at Woolwich, that they never can succeed. Colonel St. George has had four guns completed; but he not only hooped them so as to secure them laterally, but the hooping went round the back, so as to prevent the breech blow-

ing out. All four guns burst, and, if gentlemen would only take the trouble of going to Woolwich to see what has been done, they will find there these and other hooped burst guns, all marked with the names of the inventors. There is a very large family of burst guns of Sir William Armstrong—I do not speak of the coil guns, but of the cast-iron hooped guns and the shunt guns—and there is the gun of almost every inventor there, but more particularly the cast-iron hooped gun. I was present the day the Walker gun burst. I believe it stood 76 rounds with increasing charges. Perhaps it will be as well to state what that is. It is first of all fired 10 rounds with the service charge and 1 shot, 10 rounds with 2 shots, 10 rounds with 3 shots, 10 rounds with 4 shots, and so on up to 10 rounds with 10 shots, and I believe the Walker gun then stood 76 or 77 rounds without any hooping or strengthening at all. None of the guns strengthened by Colonel St. George, I was told, stood anything like the 76 rounds. I may perhaps also state, what many gentlemen here do not know, that in all these trials, at every tenth round, a gutta-percha impression is taken of the interior of the gun, and in all cases, as well hooped as not hooped, there was an invariable tendency to begin to crack at the vent. Since a cast-iron gun begins to crack in the bore without reference to the external portion—and it is only a question of time—those cracks continually extend, and it seems utterly absurd to put the hooping outside where it does not stop it. It appears to me impossible that the hooping can do any good. I am aware of the two plans of Mr. Lancaster and Captain Caffin. They were hooped all over; they were very thick indeed, and they all went at much less than the cast-iron guns without any hooping at all. If that be the case,—and the Ordnance Select Committee have got all these facts,—there is no longer guess-work and moonshine at Woolwich as there used to be; there is a record kept of every shot, the ranges and charge of powder, and every particular; I do not know to what extent the facts are published, but I have never had any difficulty in obtaining the information when it has been asked for in a fair spirit, and I presume any gentleman in the services can get this information. Here is a plaster cast of the vent of a gun; you see the cracks.

I would now allude more particularly to Captain Fishbourne's remark in reference to what he deemed service guns, and the mode of rifling best adapted to those guns. Mr. Lancaster told us generally that there were several competitors, and he did not like to mention names, the sum and substance being—I may state the fact—that his gun stood the 1,000 rounds for the simple reason that it has been fired first, and there has been no time for the others to be fired yet. Mr. Britten's has been fired 800 rounds, mine has not been fired. It takes a long time to get all these things done, and I may state, to satisfy Mr. Clay, that he is not the only person who has burnt so much powder, that even that gun of Mr. Lancaster has burnt a thousand pounds of powder and sent out an extraordinary quantity of shot.

My attention has been turned into quite another channel. Captain Blakely and many other gentlemen here, seem to have taken it for granted that it is a question of cast-iron guns or wrought-iron guns. I do not think so Many gentlemen here probably have heard of Mr. Robert Mushet, of Coleford, in the Forest of Dean, who is perhaps one of the greatest mineralogists and experimental chemists in England. For many years I have represented him in London, and when I was here last, I could only allude to what I hoped to perform. I will now state facts which I believe will go further than my opinion or the opinion of anybody else in proof of what has been done. In the first place, here is a mere cast bar of Mushet's metal (pointing to one on the table). A piece was planed out, and that piece so planed out was sent to Woolwich to Mr. Anderson to test it. I will read what Mr. Anderson said of it:—"Mr. Anderson presents his compliments to Mr. Haddan, and begs to inform him that the strength of the material tested is as follows:—1st specimen, 48 tons 16 cwt., 18 lbs. per inch; 2nd specimen, 46 tons 1 cwt. 1 qr., 13 lbs. per inch." I will now give from the same authority what the strength is of the wrought iron of which the wrought-iron guns are made—"Bowling Iron Company, 24 tons per square inch; Taylor and Company, 25 tons per square inch; best Swedish, 23 tons per square inch; Brown and Hughes, 23 tons per square inch; Blaenavon Company, 23 tons per square inch." The inference was, therefore, that if we could make a gun to bear the same tensile strength that this bar did, that there was an end of all hooping, coiling, forging, or anything of the sort. It will put an end to the question, because I presume everybody will admit, that if you can cast a gun that will stand a greater tensile strain in the proportions of two to one over any other guns, it must be better than any hooping under the sun, provided the gun will only stand. Since then, Mr. Wm. Fairbairn has made a series of experiments,

and has arrived at this result: one specimen stood 62 tons to the square inch, another specimen stood 66 tons to the square inch; another specimen stood 71 tons; another specimen stood 59 tons; and so on, the average being some 61 or 62 tons to the square inch.

Colonel WILFORD: Is that the measure of the resisting power of a gun?

Mr. HADDAN: Yes; I am coming to that. The Ordnance Select Committee, I think, took a very proper precaution, and said, "That is all very well theoretically. We dare say it is so, but we do not believe anything that we do not see. We should like to have a gun sent to try, and then we shall know what it really is." The consequence was, a gun was sent in eighteen months ago, it was bored in the Arsenal, and that was tested with the endurance round. I will read you the test; it is very short:—

REPORT of EXPERIMENT carried on in the BURSTING CELL, 23rd January, 1861.

Object.—To test the power of endurance of a 6-cwt. gun made of Mushet's iron.

Nature.	No.	Weight.			Length.		Calibre.
		Cwt.	qrs.	lbs.	Ft.	In.	
..	..	6	2	8	5	10½	3 inches.

The following Table shows the results:—

Date.	No. of Rounds.	Cartridge.		Wads.	Cylinders.			Remarks.
		Length	Weight		Length.	Weight.		
					Inches.	lbs.	ozs.	
	10	4½	1½	1	4	6	8	
	10				5½	10	5	
	10				8	13	12½	
	10				10	17	5	
	10				12	20	10	
	10				14	24	1	
	10				16	27	8	
	10				17½	30	15	
	10				20½	34	6	

An impression of the vent taken at the 90th round, shows a slight wearing of the bottom, but no indication of fissures.

Supposing, therefore, large guns can be made, you may load them to the muzzle. I have never heard any authority give any pressure higher than 25 tons to the square inch. I suppose 25 is the highest you can get. If we can really get to 60 or 70 tons to a

square inch it is quite evident you can get the gun that will never burst. There is a gun in the Institution that is made of this metal simply cast, without any forging, tilting, or hammering, but simply cast, and the gun tested at Woolwich was also cast, and was delivered rough, so that there might be no doubt on that point. The Government asked if we would deliver a 25-pounder gun. We did so, and that that might be tried in comparison with Sir William Armstrong's gun, it is turned externally to look exactly like it. It is rifled in the same way and fired with the same projectiles. That has hitherto stood the ordinary double-proof charges, and it is now waiting the endurance charge. The next step, I presume, will be to ask for a 40-pounder, and possibly a 70-pounder; and the only question will be when the ultimate results will come, because all these things take a long time to do. These guns will be very cheap, because this metal is not half the price of brass. It is a mere question of the construction whether it is to be a breech-loader, a muzzle-loader, or on any other plan you like, and by that means, supposing we can get that strength, we can then fire an elongated shot, I am quite certain, at the same initial velocity as you now get from the round shot. Mr. Lancaster and Sir William Armstrong both seem to conclude that to get the same initial velocity with elongated shot that is got from spherical shot, requires a charge of about one-fourth of the weight of the shot. I apprehend therefore Mr. Lancaster can never dream of using the service gun rifled, since in all the experiments he talked of the charge was less than one-eighth.

Mr. Bashley Britten: At this late hour of the evening, I will endeavour to make my remarks as brief as possible. Having been engaged for many years past in making experiments with rifled cast-iron guns, the only kind of guns which I have had opportunities of experimenting with, I will just give you the results of these experiments.

In the first instance, however, I will show the nature of my projectiles. This diagram will exemplify it (Plate II. figs. 19, 20, 21, 22.) Fig. 19 shows a cast-iron shell. At the base. of the shell I put a casing of lead. On the explosion of the powder the lead becomes driven up as a wedge, expands and fills up the bore, and finds its way into the rifle; and the rifling acting upon the lead gives it the desired rotation. The same principle is shown in fig. 20, a shell capable of firing molten iron. Fig. 21 is a segmental shell, and fig. 22 a solid shot. This is what I claim to be my principle for the purpose of obtaining rotation. This is the wedge. If I increase the lead wedge more, if I make the base of the wedge greater than I have shown it, the effect of it is that I get a greater area of base of wedge. The wedge is tightened up by the action of the powder to a great extent; whereas, if I keep to the point sufficient to give expansion to fill the gun, the remainder of the shot receives the powder on the base. It is not bound to tighten the shot; and by cutting this off just at the point I get sufficient expansion. All the rest of the powder goes to expel the shot, not to tighten the shot up in the gun. That is a very important point, because I find that by merely placing the width of this wedge the one-eighth of an inch the resistance becomes so much greater that it loses considerably in range and increases the recoil.

I will simply state that I have tried seven guns with projectiles of that nature. There were two 9-pounders that were fired in 1855. There was a 32-pounder 56-cwt. fired in 1856; from that gun I have fired 300 rounds. From another 32-pounder 58-cwt., in 1860, nearly 900 rounds have been fired; and from a 68-pounder 95 cwt. 300 rounds have been fired. Not one has yet been injured.

Lately, some interesting experiments have been made for the purpose of ascertaining what margin of strength there is in the guns beyond that at which I taxed them. They were put into the bursting cell. The same charge of powder that I have been in the habit of using was used. I fired from the 32-pounder ten rounds of 48 lb. service shot; ten rounds of 72 lb. shot; ten rounds of 96 lb. shot, when the gun was not injured. From another 32-pounder gun I fired the same series of shot, and then went on with ten rounds of 120 lb. shot; ten rounds of 144 lb. shot; and the gun burst at the fourth round of the 168 lb. shot. A 68-pounder was then tried, firing ten rounds of 90 lbs.; ten rounds of 135 lbs.; ten rounds of 180 lbs.; ten rounds of 225lbs.; ten rounds of 270 lbs; and ten rounds of 315lbs. with the proposed service charge of 7½ lbs. of powder, and then burst.

It seems to me that in the question that has been discussed this evening, reference has always been made to the quantity of powder rather than to the effect of that powder upon the sho Now, I think that is hardly a fair way of measuring the

efficiency of a gun, by judging of the quantity you can put into that gun. The question should rather be, which is the best gun that, with the smallest charge of powder, gives the highest initial velocity to the shot? The accompanying figure (A) represents the space occupied by the charge in the bore of the 40-pounder Armstrong gun. I believe the cartridges are 12 inches long. Figure (B) represents the bore of my 32-pounder gun, firing a 50lb. shell, which is the nearest comparison I can make to the Armstrong 40-pounder. The charge in that is one-eighth the weight of the projectile, 5 lbs. of powder. The charge in mine is 5 lbs. of powder, one-tenth the weight of the projectile. Yet, from some cause or other, the initial velocity which I get with this 5 lbs. of powder, distributed in the bore in the way I have explained, is, I believe, considerably more than the initial velocity obtained with the same charge of powder distributed in the bore in the long form. That, I believe, is a very important point.

EFFECT OF EQUAL CHARGES IN LARGE AND SMALL BORES.

(A.) Armstrong 40-Pounder.

Charge . . . 5lbs.	Bore . . . 4·	Pressure on shot 163 tons
	Area . . . 12·5	Ditto on gun 1964 ,,
←12 inches.→	Initial velocity 1200	Shot, 40lbs.

(B.) Britten's 50-Pounder. Rifled 32-Pounder Service.

				Tons.
Charge 5lbs.	Bore	6·375	Pressure on shot	415
	Area	31·9	Ditto on sides of gun .	1204
←$4\frac{5}{8}$in.→	Initial velocity .	1209·2	Shot, 50lbs.	

Pressure assumed 13 tons per inch.

Sir William Armstrong: You had better state the initial velocities.

Mr. Bashley Britten: Perhaps you will be kind enough to tell me, Sir William, whether I am right in stating that the initial velocity of the 40-pounder is about 1,100 feet per second?

Sir William Armstrong: Oh, dear, no! It is more than that; it is over 1,200 feet.

Mr. Bashley Britten: Is it over 1,200 feet?

Sir William Armstrong: I should say 1,200 feet on the average.

Mr. Bashley Britten: Then the initial velocity of mine is $1,209\frac{2}{10}$ feet per second. I think it is an important thing, because in the one case we have one-tenth the weight of the projectile, and in the other we have one eighth the weight of the projectile.

Sir William Armstrong: It is a larger bore.

Mr. Bashley Britten: It is a larger bore.

That is what I am coming to: that we lose something by the use of the small bore. I have always been using large-bore guns. It seems to me a retrograde step to us: small-bore guns. For this reason: you do not use the initial force of the powder to the same advantage with a small bore as you do with a large bore. At all events there is the fact, that with one-tenth the weight of the projectile from my cast-iron guns,

the expense of rifling which is 17*s.* 6*d.* each, that gun has an initial velocity of 1,209$\frac{2}{10}$ feet, whereas the initial velocity of the Armstrong 100-pounder is only just the same. Therefore, if initial velocity be the measure of effectiveness of a gun, I would put it whether the old cast-iron gun, with this very small charge of powder, is not equal to the Armstrong gun, the initial velocity being the same. That seems a very important question.

COLONEL WILFORD: What is the weight and shape of your projectile?

Mr. BASHLEY BRITTEN: This is one of the shot that was fired a long time ago. [Pointing to one on the table.] The shot is not similar in form now; I have improved upon it. It is now a lead-coated projectile. The lead is attached by means by which it can be so firmly united to the iron that it never separates—a plan that has been adopted by the Government for coating the whole of the Armstrong shell and shot in Woolwich Arsenal, and for which I have received some reward.

Colonel WILFORD: The gun is rifled?

Mr. BASHLEY BRITTEN: The gun is rifled. The grooves are extremely shallow, being ·08 in depth. Having been confined hitherto to the use of cast-iron weak guns, and having succeeded in obtaining that high initial velocity which is equal to the initial velocity Sir William Armstrong obtains with his enormously strong guns, I thought it only fair that I should be allowed to compete with him on equal terms; therefore, I have applied to the War Office for a nine-inch gun to be made on that very beautiful principle which Sir William Armstrong has introduced, being, as I believe, the only means of making extremely strong guns now. The gun I have proposed should weigh six tons, be nine inches bore, and ten feet long. I have proposed it as a broadside gun for the navy. I think that gun can be fired with 17 lbs. of powder as a rifled gun, and with 24 lbs. of powder, as a smooth-bore gun, to fire shot; and the grooves being so extremely shallow, there would be only a very small escape of windage, compensated for by a trifling increase in the charge of powder, without increasing the strain upon the gun. Although that might not in itself be sufficient to penetrate the very thick plates which it is proposed to put on ships, it is a question whether as a broadside gun the concentrated fire of three or four such guns, would not produce more effect than a single shot from a still larger gun. I have proposed that for a broadside gun. Whether the gun will be made, is a question under consideration.

There is one point to be considered besides. In all my experiments in which it has been shown I have obtained this high initial velocity, I have not increased the recoil of the gun. The principle I have gone upon is this. I did not know the strength of the cast-iron gun; I did not want to tax it too much; therefore I thought, if I kept within the usual amount of recoil, that I was not increasing the strain beyond what the gun would bear. Therefore, if these experiments of mine show that we can produce a cast-iron gun with the same initial velocity as the Armstrong gun, and the same range up to 23 deg. and 24 deg. of elevation—and up to that elevation itself the trajectory is as flat as that of Sir William Armstrong's—it is clear there must be something in this principle which I think fairly justifies me in asking to have these guns tested against Sir William Armstrong's; not cast-iron guns against wrought-iron guns; but wrought-iron guns against wrought-iron guns.

A gentleman said just now you could not use rifled guns of more than a certain weight in consequence of the excessive recoil. Now, in these experiments of mine, in which I have got these long ranges and these high velocities, the recoil has been less than the recoils of the same guns with the old service charge. In fact, I have regulated my charges by that means. So long as I did not increase the recoil beyond what is the usual amount of recoil, I thought I was safe, and it has been shown I have not burst a single cast-iron service gun. They have stood, not one has failed, and I have tried seven of them.

Whether these cast-iron guns are capable of being rifled is still under consideration; I think the Committee are pretty nearly in a position to come to some definite conclusion on the subject.

The discussion was adjourned till the following evening.

ADJOURNED DISCUSSION.

Wednesday Evening, May 21.

W. Stirling Lacon, Esq., in the Chair.

Mr. Michael Scott, C.E.: I shall be very glad to submit a few observations; but it will be with a good deal of diffidence in the presence of such an audience, inasmuch as I am not professionally connected with this subject. To me, Sir, it is a matter of purely scientific interest, and I shall make my observations as brief as possible, especially after the intimation which we have received from you.

In the first place, I would wish to say a few words upon the subject of breech-loading guns. We all admire the great ingenuity displayed by Sir William Armstrong in constructing his gun, but I think in the case of the large-bore naval gun, breech-loading is a mistake. I was puzzled for a long time to guess at the supposed advantages of breech-loading; but, as they were stated by Sir William Armstrong at the last meeting, we can have no longer any hesitation upon the point. The first advantage he stated was, that the men who were working the gun were not so much exposed. That is a point which must be left to naval officers to discuss; it is one which I cannot touch, and do not profess to have any knowledge upon; but I hope, as there are several distinguished naval officers present, we shall have some information upon it. The second advantage stated by Sir William Armstrong was, that a longer gun might be employed in narrow ships. Now it appears to me that the gun which will be required to deal with these iron-plated ships, will necessarily have a very great recoil. If the shot has a high velocity and is of considerable weight, the recoil of the gun must necessarily be great; and therefore the advantage that might have been claimed on this ground for the guns hitherto used in the naval service, may not be so apparent in the new guns that will require to be constructed to deal with the iron-plated ships. I will subsequently submit to the meeting a table which will show the amount of recoil that must necessarily follow the momentum that is communicated to the shot, if that shot is to have any effect upon the iron-plated vessels. The disadvantages of breech-loading, I think, are very apparent, when it is applied to large guns. In the first place, they are weak—I think necessarily and essentially weak. The answer to that may be—I think it was stated by a gentleman at one of the previous meetings—that the guns that have been constructed, are strong enough to bear the strain that they have been subjected to, and therefore there is an end of the question. But I think it is hardly the end of the question. A seven-inch gun made of wrought-iron has been found strong enough; but it follows, that if that gun of seven inches in diameter is strong enough as a breech-loader, a gun ten inches in diameter as a muzzle-loader would be as strong. If, therefore, it be an advantage to have the large guns, I certainly think that the muzzle-loader would have the advantage in the matter of strength. The case is very much this. In the case of the muzzle-loader, it may be considered, that the strain is applied in the middle of a tube, to burst it; in the case of a breech-loader it is applied at the end. It appears to me, therefore, to be very clear that the muzzle-loader having a closed end must have at least double the strength of the breech-loader having an open end. The fact of their being weak involves a small diameter; and, if breech-loaders are not weak, it is a very remarkable fact that we have not a gun of large diameter, a breech-loader. I do not know of anything above seven inches. If breech-loaders are equally strong, why not have them of larger diameter? In the case of the last gun that has been tested, so far as I know that gun, it was ten inches or ten inches and a half in diameter. It was not a breech-loader; it was a muzzle-loader. I am not aware that Sir William Armstrong has ever applied breech-loading to a gun above seven inches in diameter. If the guns are small in diameter, it follows that the capacity of the shell is small, and that the weight of the shot must be comparatively little. Further, the initial velocity is low. Now, if those guns made by Sir William Armstrong are of such vast strength, why not increase that initial velocity? Naval men tell us they want that velocity, and we know that the destructive power of the shot is as the square of the velocity; therefore velocity is a very important matter. But it appears from what Sir William Armstrong said on the last occasion, that the velocity from his gun is 1,210 as against the velocity of the ordinary 68-pounders, which is 1,580;

and, although Sir William Armstrong has a shot weighing 110lbs., he shows by his own figures that the relative effect of these shots from the 68-pounder is 17, and of his shot, on account of the lower velocity, although it has a much greater weight, only 16. Now this velocity is wanted, urgently wanted. If there is any hope of penetrating the plate, it must be by velocity; and the power of the shot increases directly, not as the weight, but as the square of the velocity. If it can be obtained, it is very desirable; but it has not apparently yet been obtained by any breech-loading gun. If the initial velocity is low, as I have just said, the force of the blow and the penetrating power of the shot must be small, and it would appear from the figures supplied by Sir William Armstrong on the last occasion, which are still on the board, that the penetrating power, the *vis viva*, the living energy of the shot, of the 110-pounder (I speak, of course, of close quarters, at the muzzle of the gun—I am not referring to long ranges at present) is only 16, as against the old 68-pounder spherical shot 17. In addition to this, there is in the Armstrong gun a great complication of parts, which are liable to injury. They are expensive; and if we compared the effect produced with the cost, the effect being less of the 68-pounder, I believe the immoderate expense would be very obvious. I do not know that it is desirable to say anything more upon this branch of the subject.

I shall confine myself to a veryfew remarks upon the shot and gun best adapted for dealing with plated ships. Spherical shot indents the plate; and the shot, if of cast-iron, breaks. Now, if it is desired that the shot should penetrate a plate, I say that the whole power absorbed in the indentation, in the bending of the plate, and the breaking of the shot, is lost. Flat-headed shot would neither indent nor draw the plate; and it has this advantage, that the impact being distributed over the whole of the surface, instead of being concentrated on a point, and at the same time—the impact taking place in the direction in which the shot is strongest—that is, vertically in relation to the surface, if it is intended to penetrate the plate, the flat-headed shot would unquestionably have the advantage. It might be objected that the flat-headed shot would meet with greater resistance from the air. Now this is a point of considerable interest; and it has been examined by a gentleman of the highest scientific qualifications, Mr. Froude.

Admiral Halsted: I shall be happy to place at your disposal a reality, instead of the supposition you are giving us. Here is the actual measured plan of the effects of firing the 156-pounder shot on the Warrior target, on the 8th of April last.

Mr. M. Scott: I have not had an opportunity of consulting that.

Admiral Halsted: Of course you have not; but I mean to say that what you are putting before us is a supposititious case, and you are perfectly welcome to use that diagram, for that is a reality.

Mr. M. Scott: I am very much indebted to you, Sir, but it would be difficult for me to examine it. It would be difficult for me to digest this diagram at the present moment. As I stated at first, my interest and connection with the subject is purely scientific. I am reasoning the matter from first principles. I know nothing about the experiments that have been made by the Government, and I do not profess to be able to say anything about them; I merely submit my views for what they are worth. Mr. Froude has shown that the resistance in the direction of motion to a plane moving obliquely is the same as the resistance to the plane at right angles with the line of motion, which is subtended by the oblique plane if the angle of obliquity is not less than about 60 deg. If so, we have then the condition of a pointed shot, as compared with a flat-ended shot. It would therefore appear that the resistance due to the pointed shot is the same as, and no less, up to the limit of 60 degrees, than the resistance of the flat-ended shot. That seems to be proved. I confess that I can see no error, nor has any one else that I know been able to see any error, in that conclusion. In the case of spherical shot, it may be argued in their favour, that, supposing they do not penetrate the plate, at all events the whole of the power of the shot is expended on the plate, whereas the flat-ended shot may go through and have a considerable power left, and, if it has no work to do inside the plate, that power will be lost; but in the case of shells, I apprehend, no influence will be produced, unless it does penetrate the plate. Therefore it would be desirable that they should be made flat. Now, I have been always told that, in the case of those partially plated ships, the ordinary spherical shell will not penetrate even the thin plate, and that, therefore, all they have got to fear is solid shot. But I can easily conceive that a flat ended shell might be able to penetrate the thin plate, and might have very great destructive power when it had passed through that plate.

I will not detain you longer, Sir, upon that point, and I fear that perhaps I have

detained you too long; but I wish to say a few words upon the subject of the size of gun that can be obtained for naval purposes, and to deal with iron-plated ships. Now, to penetrate a 4½-inch plate, for instance, requires necessarily great force of shot. That force is made up of weight and velocity; and the limit of the force of the shot is the strength of the gun, which of course is determined by the strength of the material. Assume, for the purposes of argument, that the material is wrought iron, and that this material is three times stronger than cast iron; and assume that the strain of the cast iron is equal to that of the iron in the 68-pounder; then, I think, it can be determined theoretically what would be the bore of the guns for different weights and velocities of shot; and I have constructed a table for the purpose of illustrating this. The accompanying table shows the weight of shot which may be fired from wrought-iron smooth-bored guns, of various sizes and with various velocities, without straining the metal more than the metal of guns in the service is already strained. The type of the service gun I have taken is a 68-pounder.

Bore of Gun.	Weight of Shot for velocity of feet. 2000	feet. 1750	feet. 1100	Weight of Sphere.	Weight of Elongated Shot.	Velocity of Elongated Shot.	Force of Blow of Elongated Shot.	Momentum of Recoil from Elongated Shot (Col. 6).	Weight of Gun, to give same Extent of Recoil.
inches. 8	Ordinary 68-pounder.			lbs. 70	lbs. ..	feet. 1600	1·0	1·0	tons. 5·0
7	lbs. 118	lbs. 154	lbs. 390	47	93	2253	2·64	1·87	9·35
8	135	176	446	70	140	1964	3·02	2.46	12·30
9	152	198	502	100	202	1734	3·40	3·13	15·65
10	168	220	555	131	273	1565	3·75	3·82	19·10
11	185	242	611	174	366	1422	4·13	4·65	23·25
1	2	3	4	5	6	7	8	9	10

Column 1 gives the bore of the gun in inches; column 2 gives the weight of the shot which may be fired with a velocity of 2,000 feet per second; column 3 gives the weight of the shot which may be fired at the velocity of 1,750 feet per second; and column 4 gives the weight of the shot which may be fired at the velocity of 1,100 feet per second. The next column gives the weight of a sphere of the diameter stated in the first column; the next is the weight of an elongated shot of two diameters length, but not solid, hollow behind; the next gives the velocity of that elongated shot; and the next gives the force of the blow, that of the 68-pounder ball, taken at 70 pounds in round numbers, moving at 1,600 feet per second, being taken as one. The principle upon which this table is calculated is very simple; but it involves a great number of figures. I have stated publicly on previous occasions, and I do not know that it has ever been disputed, at all events I place in the hands of the Secretary of the Institution the details of it. I do not know that it can be disputed, because there does not seem to be any dispute whatever with respect to the theory, namely, that the power of the shot is the *vis viva* of the shot, the living energy, the weight multiplied by the square of the velocity. If that be so, then the only other element is the diameter of the gun. The

force of the blow, you will observe in column 8—and it is somewhat important—varies very considerably. The argument is this—assuming wrought iron, in the first place, and assuming that wrought-iron is three times as strong as cast-iron, that without straining the metal of the gun more than the metal of an ordinary 68-pounder is strained by firing a 70 lb. shot at 1,600 feet per second, this is the effect. These numbers represent the force of the blow, or the effect produced by the shot from these varieties of gun.

A Member: May I ask, what charge?

Mr. M. Scott: It is quite irrespective of charge. The question has nothing to do with the quantity of powder. It is a relative question—not an absolute. I do not profess to give the absolute effect; I do not know that it is possible; at all events, as far as I am concerned, I do not profess to deal with it at all. If you fire a 68lb. ball at the velocity of 1,600 feet per second, that is represented in this table by the figure as 1; and, if you fire any of those other weights at those other velocities stated in the table, the *vis viva*, the force, the destructive energy of the shot, will be as represented in this column, without reference to what the powder may be. It may require one pound or a thousand pounds of gunpowder; it does not affect the relative question. It affects the absolute question, no doubt; but the relative question is not affected, and the table is merely a relative table, to show what the effect of various diameters of guns and various weights of shot would be. From this table it appears—and it is a somewhat curious result—that for a given bore of gun, whatever be the weight and velocity of the shot, provided these vary in such relations as to keep the strain on the gun the same, the destructive power of the shot always remains the same. I think that is a point of some importance, and I am not aware that it has ever been stated before. I think important results will flow from it. For example, one conclusion would be this—that a light shell, provided the material of the shell was strong enough to bear the impact, would penetrate at very close quarters, because all these calculations have reference to the velocity at the muzzle of the gun—would penetrate equally with a heavy shot.

A Member: If it did not break up.

Mr. M. Scott: Assuming that the material of the shell bore the impact as I say, provided it did not break up, the light shell, having the higher velocity, would penetrate quite as readily as the heavy shot with a low velocity; and it would appear from that table, that this is a fixed quantity, an unalterable quantity, provided the strain of the gun remain the same. In reference to any given diameter, you have the figures, which show that, no matter how you vary the weight and the velocity, the effect at the muzzle of the gun must be the same. Without detaining you, however, any further upon this point, I would just say a few words upon the recoil of guns. That is a point, surely, that is practical, and surely it is interesting. The ninth column of the table represents the recoil for the elongated shot in column 6, and the velocity is in column 7. The column marked 10 gives the weight of gun to give the same extent of recoil as an ordinary 68-pounder; provided the resistance, the compressors, and other artificial means, be increased in proportion to the weight of the gun. I think it is a practical question for the naval officers present to determine, whether they can deal with guns of 12, 15, 19, and 23 tons. If they cannot, it necessarily and inevitably follows that they must expect a greatly increased recoil—increased in velocity, and increased in distance. As for example: suppose you take the 9-inch gun, the weight of which, to give the same recoil as the 68-pounder, would be 15½ tons. If that be found inconvenient, possibly it might be diminished; and, suppose that the weight be diminished to one-half, the distance of recoil will be increased four times. If you diminish the weight of that gun to one-half—suppose you make it between 7 and 8 tons—the velocity of the recoil will be doubled, and the distance of that recoil will be four-fold. If, therefore, the recoil of an ordinary 68-pounder is 8 feet, the distance to which that gun would recoil would be 32 feet. That, I say, appears to me to be a matter of considerable practical importance, and one that would be very well worth the consideration of the naval officers present.

Gentlemen, I will not detain you longer; I will merely say this—that, although these statements do not appear, perhaps, at first sight, to be what you may call practical statements, that is, that they are not the result of absolute experiments with individual guns, there is not the slightest doubt about the principle. It is not to be disputed, and, therefore, it must have a very considerable bearing on the practice.

Commander Robert Scott, R.N.: In following those who gave you such very well-digested speeches on the merits of their own plans last night, I am placed at great disadvantage, for it was not my intention to have compared my own propositions with those

of others, except in a very general manner, having already given publicity to them here, as elsewhere; and I am strengthened in this view by the able discussion of them by Captain Fishbourne, and I remember, also, the old proverb, "Let another praise thee, and not thine own self." I should, however, be admitting the correctness of what has been here asserted, did I not oppose facts to those assertions; and, therefore, with your permission, I will examine a little more closely into what Mr. Lancaster stated last night; as, if correct, the rifle question is certainly settled in favour of the oval; the exterior of the lead, he said, gave off in fumes, and the grooves, at any rate—pointing to mine—the grooves, he said, crush up, and, as grooves crush up and lead evaporates, the only remaining plan is the oval. I trust, however. to convince you that Mr. Lancaster is quite as much beyond the mark in what he mentioned last night—I am sorry to mention names, but, the comparison having been made, I am of necessity forced into it. I cannot help it, and I hope you will see that; because, if my groove crushes up, what is the use of my gun? It is evidently a useless thing, and all that has been advanced is mere moonshine. However, as I have said, Mr. Lancaster is quite as much beyond the mark as he was when he wrote to the *Times*, and mentioned that his own gun had fired 284 rounds, which I know that he afterwards admitted not to be correct. Again, Mr. Lancaster said in this very letter, that Mr. Jeffrey's shot and my own were forced home by a heavy metal rammer, the same which had to be applied after double sponging, in order to force home each of his shells which had been carefully turned to one exact windage. In my own letter in reply to that, which also appeared in the *Times*, I said, that, if the heavy metal rammer had to be used in practice-ground under such circumstances, it certainly would condemn any such gun for naval purposes *in toto*, but it was not used with my gun. And I will ask this, and there are several naval officers here, who, as well as myself, have seen the oval gun fired, for I was at Shoeburyness in 1854, and was sent purposely there. I need not read my own notes on the subject; I shall be very happy to let any of those officers see them, and my report to the then Controller. We have seen the gun, and we know exactly what it has done; and, had the oval been a good gun, should we have thrown it aside altogether? or would they in the Crimea, when it was of such consequence to fire a shell with a large bursting charge, have entirely given up the oval, and continued to fire the round ball, which, of course, had a short and unequal range from the gun? I leave it to yourselves to judge whether such would be the case. However, it would be beside the mark did I give all my objections to the competitive trial, prior to which my gun had fired so many more rounds than Mr. Lancaster's and others, excepting Mr. Bashley Britten's (I am not going to touch on Mr. Britten's gun), and completed them within a much less time. My gun had been bored, rifled, and fired up to 300 rounds, as fast as the shell could be recovered, and the days afforded to me to carry out the experiment at Shoeburyness, would allow. It certainly never entered into my head, on the score of injury to the rifling, to object to the competitive trial, although my gun had previously fired 300 rounds, for at their conclusion the assistant superintendent, with myself, examined the gun most carefully, and we could not see a line in the gun worn down, and he said to me, "The bore appears quite perfect." But are there any other indications? Yes, when the shot were fired rough at first, and not smoothed off as I fired them there, and a soft metal put outside, the same soft metal that Sir William Armstrong afterwards used in solid strips (or even perhaps before, but I think it was afterwards) I put on liquid zinc, forming a beautiful coating, placing a soft metal in front of a hard bearing, which could not possibly give way. But, before that was done, the paint of my shell was really merely smoothed down after firing. It seemed so extraordinary a fact, that when it was mentioned to Captain Blakely, and also to Mr. Lynall Thomas, both these gentlemen inquired into, and examined the case for themselves; and so did the Admiralty. But is that all? Certainly not; fifty shells completed 300 rounds. There were some few new shells introduced, with which I tried an experiment, which is not worth while going into here, but about forty-six of these shells were recovered off the range and re-fired. That is how the 300 rounds were made up. The Report states that not one of these shells was cracked, and the assistant superintendent said to me, "I consider the shells are still serviceable." One of these shells is now in the Exhibition. If the bearings of the shells had been scored, or if there had been rubbing or crushing, it would certainly have shown itself upon them; but as nothing of the kind took place, and as I made some objections to the Committee's trial, I should certainly have objected *in toto* if I could have detected the least irregularity upon the line of my rifling; but such was not the case. As far as human eye could judge, and I examined the gun several times with those at Shoeburyness, it seemed perfect.

But, as the gun has been compared with his by Mr. Lancaster, that is not the only point

in which it should be compared. The shells were all easily loaded, as I have now said; but what took place as to the other shell of the oval with which my gun has been compared? The first shell that was fired in this competitive trial went out of the gun broken up. A per-centage of those that were picked up, seen by Mr. Haddan as well as myself —who can say whether it is the case or not—I have not spoken to him on the subject, but he happened to pass as I was examining the heap to look for my own shot—a considerable per-centage of these shells were cracked also. The reason of that cracking is obvious. Suppose you take a flatter groove—my groove (Plate I. fig. 8 *g*)—the shell of course has a bearing upon that groove, and comes out in consequence easier. But cut away that groove, and bring it round and make it into an oval, there is then no bearing, and, unless the shot is exceedingly tight, you can see there must be considerable play. Now, the gun turns the shot, and the shot has to come out grinding against the bore, and I ask any one who understands what friction is, whether there is most friction with the plain or flat bearing, or with the oval bearing, and a shot that wedges itself round against the side of the bore?

Not only so, but I think it is apparent to everybody, that, under most cases, such a wedging open would be much more liable to burst a gun than grooves such as I propose. The strength of cast-iron guns is very unequal; were the cast-iron equal we should have fewer cases of bursting; but I think most of us know of many cases of bursting that have occurred. When I was at Shoeburyness a gun burst and it broke the legs of three serjeants; it was a gun of the oval bore.* We know that three Lancasters burst in the Crimea, and therefore, speaking of bursting, we are pretty much—as Mr. Haddan expressed it—" in the same box, the whole of us."

Experiments have been put forward, and they may be again put forward, as indicating the relative value of different systems of rifling, and therefore it is really important to examine into what has been tried. There happened to have been competing together the shunt of Sir William Armstrong and my own gun with grooves, Mr. Haddan's also with grooves, (though shallower and swept out more), and, on the other hand, Mr. Bashley Britten's, and Mr. Jeffrey's, and the oval bore. Now this list completes the whole that were competing, and, as it takes in the whole, it is necessary to dwell a little more on this subject. I think that the endurance of one gun, does not prove much; the opinion of the President of the Select Committee certainly was in the same direction, for, when he brought forward the plan of strengthening, mentioned last night by Mr. Haddan, he at once tried it upon four guns—two sixty-eights and two thirty-twos. Could it have been settled by one gun, I imagine he would not have taken four guns for such a purpose. I think we must all admit, that we have been somewhat mistaken as to the strength of cast-iron. When 5½ pounds of powder have been fired with the lead-coated shot, the guns have gone; with 5 pounds they have stood. When over 6 pounds has been fired with the iron shot, those guns have also gone; therefore, if we are to use the unstrengthened cast-iron guns, we shall have to use a very low charge. When Mr. Whitworth's gun burst, which was a 68-pounder rifled on his plan, they asserted that the shot stuck in the bore; it was referred to Mr. Anderson, who at once said that what surprised him was, not that the gun burst, but that it stood at all.

Much has been said as respects lead-coated shot. Speaking of Sir William Armstrong's grooved gun, it is clear it is not suited to high velocities; and I think that it is shown by Sir William Armstrong himself, for he has only used the shunt with high charges of powder. The shunt has been fired with 20 pounds, but the other guns certainly will not stand large charges of powder—they cannot be fired with large charges of powder. It has been said in this Institution that a large charge of powder was used in the 110-pounder gun. Yes, but the lead in the rear is then cut away. I have examined many of the 110 lb. shells, looked at those very narrowly that have been picked up after firing, and I have observed this, that while with the longer bearing of the shell the slip upon it is very slight, with the shorter bearing of the shot of the same weight, the slip upon it is considerable. But you will ask me " How have you ascertained the slip?" I think I could show you how. The width of the groove and the width of the lands we will assume as being nearly the same. Now, the lead on the shot that has come out of the gun, if it does not slip, ought to be fully the width of the land; but instead of that, it is not. In the solid shot it is not more than half the width, and in some cases I think, it is less than half the width, almost up to a point; and any of you who will examine the shot fired, will see exactly the

* We are requested by Captain Scott to state he confounded this gun with another of Mr. Lancaster's, which burst on a different occasion, viz. on Jan. 31, 1856.—Ed.

same thing and how that is indicated, and, if you examine those fired at the butt, it is true they show the rifling, but how much that rifling has slipped round, it would be difficult to say.

However, there was another assertion made here, and I think what I have said of the shunt indicates, although Sir William Armstrong does not quite agree with it, that the detaining of the projectile is damaging; he has said it is an advantage. If detaining the projectile be an advantage, I imagine that he would not have made his last breech-loading gun a shunt. It was tried against the Thornicroft plates down at Shoeburyness. On that occasion the wedges stuck fast; afterwards in trial, on being brought back, the wedges broke, and the gun itself was returned to Elswick. It has come back, and has been housed in the arsenal store ever since.

Breech-loaders have been spoken of, and I believe Sir William has gone to the limit of size in breech-loading. In fact, he allows, as we know perfectly well, you cannot lift out the vent-pieces. One of the strongest men at Shoeburyness said to me "It is the easiest thing possible, just try, I like to convince you." I said "I am very happy to do it," and we commenced lifting out the breech-piece. But after we had lifted it out two or three times he had enough and did not wish to lift it out any more; and I can tell you we had a great deal of difficulty in dropping it down exactly in its place. And therefore, with breech-loading, the fact is, over seven inches it cannot be worked at all; you may take any breech-loader you like, I have not seen any of that size that can be worked.

It is confessed that a naval broadside-gun must fire a heavy charge, and I certainly think this element of weakness the breech-loading, should be eliminated from the gun. To pass on, however, Sir William has told us an effective broadside-gun must have a large bore, in order to have a high velocity, and this of necessity entails firing a round ball, and therefore that the new naval gun is to be a smooth-bore. If not presumptuous in one who has all his life studied the subject—because I do not come before you without having studied the subject; in 1854 I was sent to Shoeburyness in order to keep the Controller-General of the Coast Guard informed of what was going on in gunnery there, and to report to him whatever was likely to be beneficial to the navy. Mine are the ideas of a whole lifetime, and I may say I have passed years in devising and carrying out what I believe to be a very simple and easy mode of uniting the advantages of the smooth-bore and rifle in one gun I would especially say it is very desirable to unite them, and for this reason—that we really do not know, what form the attack or defence in future warfare may assume—a point I hope very soon to hear discussed in this Institution, and I am quite sure some very valuable facts would be brought forward in relation to ship-building and other points. I hope Captain Coles, whom I see present, and whom I believe has spoken of giving us a paper, will do so on an early occasion. It is a subject of really national importance, and we shall all be delighted to hear him; on that ground there is no difference of opinion; I am sorry to say on the rifle question a very strong amount of feeling certainly does exist. The new gun that Sir William Armstrong is now manufacturing, is 106 inches long in the bore, it is 9·22 inches in diameter, it is to weigh 112 cwt.; that is the exact dimension of the gun, but I think I need not give my opinion farther respecting it. However, from such a gun, if rifled, shot whether flat or round-headed (for this must depend on the form and outside of future vessels) with a shell rear would prove very effective by bursting between the plates and backing. There are many mistaken ideas about shells. I think there are one or two experiments that Captain, or rather Admiral, Halsted has watched very narrowly. When the shell was thickened in front, it was found that it passed through a plate of three inches and did not break up—I am now speaking from memory. Captain Inglis of the Engineers gave a lecture on penetration of shot, and I would recommend all who are interested in the question to get it. There are many experiments recorded that I tried in vain to get elsewhere, and many of them are of very great value. However, with respect to that, and as illustrating in some measure what Mr. Michael Scott, whom I never had the pleasure of seeing before to-night, has stated, I believe that the same penetration which is here given, an inch and a half, was attained by the shell fired from the 68-pounder. It went with a very high velocity, and if we can give that, without over-weighting our projectile, so much the better. I do not see the necessity of what Sir William Armstrong has here said about doubling the weight of the projectile, because, in doubling the weight, of course you increase very considerably the strain upon the gun. I think you may cast your projectile considerably lighter, with a cutting flat front, and shell in the rear, which would

cut through or at least penetrate far enough to discharge its small mine, and do considerable damage inside the armour plate; I believe it will be found to be a very destructive kind of shell, and a shell we shall possibly have to use in future warfare.

A MEMBER: Are you alluding to the smooth-bore?

Commander SCOTT: I am speaking of a rifle gun; but I speak of combining the two, and I say we must have a gun of this description at once; it is no use going on as we have been. We have had one era of artillery, and we have gone on and made an immense number of guns, I believe opposed to the opinion of every naval officer who has considered the subject at all. I know it was stated at meetings nearly two years ago that we were really retrograding in going to small-bore rifled guns, and I think it is now very desirable not to take a turn in the other way, and hold on to smooth-bores entirely, but combine the two, for we do not know what future warfare may really necessitate. One of the most important things that has been very much overlooked is that of molten iron. The molten iron will fill up the shell and make it almost solid, so that you will at first have the full blow of the molten iron, and, unlike powder, the molten iron, if you can pitch it against anything, will stream over it; it may stream into the port. This will be found, I believe, a very fearfully destructive weapon. The Armstrong gun will not throw it, that is, practically it will not do it. The small round shell contains too small a quantity to be effective. What we want is a large quantity; but even the less quantity sufficed to set a vessel on fire; and when it was tried, although they had the engines and everything ready, as is well known to Admiral Halsted, they could not put the fire out.

With regard to the recoil, I believe there are very simple means of reducing it. India-rubber behind the trunnions, I think, will do it; that is, it will save the gun, by lessening the strain. Sir William Armstrong mentioned the bore of the gun being soft, and wrought-iron is very soft, and that it might be necessary to use a sabot. There was a kind of one used when we actually did fire round-ball out of my rifled gun; not that it was necessary. In that particular gun we used a small wad made by Mr. Belfield, which answers all the purposes, and can be made for about 3*d*.; but I trust we shall have a bore sufficiently hard, whether of steel or some other metal, so that we shall not require anything of the kind, and I look upon every addition as of course complicating the gun.

To return to our present cast-iron guns. Colonel Lefroy has stated, they have been long known to be improved by a reduction of windage, but they wont't stand it (these are his words). Has it ever been tried, because I can find no experiment of the kind, to make a reduction of charge equivalent to the reduced windage, because then you will have accuracy, and you also save powder. I am not aware of any experiment, either, to test the increased accuracy arising from a more exact boring of the gun. Some may not be aware, that none of our guns are truly bored, and the few that are, are the exception; the rule is they are bored roughly, and I believe it is a considerable element of error, and one that does not appear to have attracted much attention. But as the 68-pounder now stands, it is accurate, and some excellent shooting has been made with it, and, if I mistake not—in fact, I know it is the case—at 300 yards at Shoeburyness it beat the rifle guns on one occasion, though pointed by Sir William Armstrong himself. I believe where the charge is increased, the accuracy would be much more sustained; instead of stopping at 16 lbs. of powder, we could go up to 24 with our 68-pounders. Now we cannot do it with the guns in their present state, and, as the Duke of Somerset justly said, it is very desirable to do what we can with our present stores. Now Captain Blakely has proposed a plan for simply hooping. Mr. Lancaster proposes to encase the gun; and Mr. Haddan says the guns are not strengthened by either method. First, with respect to Captain Blakely's method of strengthening. Here is a trial of strengthening, by order of the Select Committee in 1835, which Captain Blakely has put into my hand, in which I find that the Blakely gun stood an immense amount more firing than any other.

A MEMBER: What size gun was it?

Commander SCOTT: I gave the size in a former lecture here.* Perhaps you will kindly look at it; my memory does not serve me. I think I ought to pause here one instant, as Captain Blakely has taken my rifling, but with my permission. I asked the

* See Lecture on Progress of Ordnance at Home, &c., p. 18, vol. VI., Journal of the Institution.—ED.

Admiralty if they had any objection to his doing it; when Captain Blakely spoke to me about the matter, and kindly offered me something, I said, "The only thing I have to say about it is, that you will please to consult me about the rifling, that I may see that it is well done." I cannot say that he has always consulted me on the subject; I believe it is, that he thinks it would put me to trouble and expense, but I should always be very glad to see him on the subject. I may mention, however, that Captain Blakely examined that gun of mine that was burst, and wrote to say that he found the rifling not at all injured. I have to stop here one instant, and I am sorry I omitted it, to speak of the endurance exhibited by the different competitive guns. Now, among the guns fired in the competition at Shoeburyness, excepting my own and Mr. Bashley Britten's, there was no gun that had fired near 300 rounds, and our guns had fired them at elevations. The guns that completed the sixty five competitive rounds were taken from Shoeburyness, where they had been fired at elevations, mounted on their carriages, placed in the cell at Woolwich, and suspended horizontally on a swing. The consequence was, on the first impact of the charge, the gun recoiled; and my own opinion is that Mr. Lancaster's gun, if it has fired 1,000 rounds, will probably go on and fire 2,000 more; for every one knows what a different thing it is to fire a gun horizontally, and suspended where it will at once recoil, and these differences were my reasons for objecting to my gun being put into the trial. When my gun did burst, the coated shot were somewhat in favour, and iron-shot, if possible, were to be set aside. Various hypotheses were set up about the bursting; but, when the pieces of my gun were brought together, it was found there was a very bad flaw in the bore, and, when I managed to get hold of my ten shot and examined them (only ten rounds were fired in this competitive trial before my gun burst), I found the shot were scratched along their bearings, showing that the gun had been gradually opening. There was nothing but what is straightforward about the matter; there had been various theories put forward, and I have no doubt, those who advocate lead coating, as is generally the case, wish to believe what they wish to be true.

But I have wandered away, and I must apologise to you for it, from Captain Blakely's strengthening. After seeing Captain Blakely's hooping, it struck me that putting it on straight in one piece, would be better. I have not seen it; but I also know at the same time that any man would put it on in one piece, if it were not for the expense; it is more expensive to put it on in that way. Mr. Parrott, in America, I find since I gave my last lecture, says his plan differs from that of Captain Blakely, in that he puts it on in one piece, whole; and it is precisely that mode by which he gets the increased strength, and I have no hesitation myself in expressing my firm belief, that such a mode of strengthening, if the jacket is carefully put on by hydraulic pressure at a certain force, is the best, and I will give you a reason for it. In the Armstrong gun at the end, there is a large piece; it is a forged breech-piece, and I believe it is the only part of the gun which I have never seen broken. Hoops are welded immediately against this forged piece, the grain of the iron running in a different direction, and over this another coil is put. They are two different sorts of iron. If over the wrought iron the coil gives strength, why should not the coil over the cast-iron give strength, provided you regulate the tension properly? I allow in the proof in the cell, the hooping may not appear to strengthen the gun in any great degree, and for this reason, the proof in the cell consists in gradually increasing the weight of the cylinders, the first cylinder being heavier than any shot you would fire out of it.

I believe the hoops prevent the iron from disintegrating. You know the particles are merely laid together; they are in close proximity, but there is no interlacing of fibre; and the continued concussion opens them, and, if opened, any gun will go—continuous fire, is proved always to destroy the guns. I believe hoops, however, will prevent disintegration, and, if you prevent that, I have no doubt in my own mind you could make our present 68-pounder, hooped in such a way, a strong durable gun, capable of firing 24 pounds of powder.

Mr. Lancaster proposes to encase the gun, and he says that a cast-iron interior would be less liable to injury than one of wrought iron. If Mr. Lancaster proposes to apply the plan to our present guns, I believe the expense will be an insuperable objection to it, for if you cut away the trunnions—I do not enter into the question of putting the casing on, it will be rather difficult, but it is a difficulty that may be got over. I think the expense will be exceedingly great; quite half that of a good wrought-iron gun. If he intends to hoop new castings, it may be asked, would not a less brittle metal be better?

I certainly should prefer myself good wrought-iron to cast-iron, and would venture to suggest as an experiment that might be easily tried, to take one of the Armstrong guns, that have been used in proving vent-pieces, of which there are four—the coils are opens so that they are of no further use—and let it be fired at. There is the muzzle also of a good forged gun, that of Mr. Lynall Thomas, which might be fired at, and also that of a 68-pounder. Then you would come at once to the respective endurances of the three, in being fired at. But with regard to Mr. Lancaster's gun that he speaks of here, there was an endurance mentioned of 81 rounds. I am satisfied that I was not mistaken in stating that that gun was considerably heavier than the 68-pounder; and therefore it is not surprising that if the gun be very much heavier it should stand a very much larger number of rounds.

I am sorry I have taken up so much of your time, and I will conclude with only one observation about the Armstrong gun. A gentleman thought that he would investigate the matter for himself; the Captain of a man-of-war was a friend of his, he went on board, and at his request the captain sent for the gunner and the gunner's mate. There was an Armstrong gun on board, and they showed him everything about it. He took the gunner aside, and said "Tell me what is your candid opinion about it;" and says Jack "Well, Sir, my opinion is that it is a werry dangerous gun."

Admiral TAYLER, C.B.: As the time is very short, I shall only make a few observations. In fact, the very able discussion we have now had from Commander Scott, renders it totally unnecessary for me to expatiate more fully on anything that has been said, because I fully agree in everything he has stated.

I will, therefore, briefly describe to you a gun of my invention, and also a conical ball,* and I believe I was the first person who brought forward conical balls. In the year 1842 I proposed conical balls, and Admiral Sir Philip Durham wrote to Marshal Soult mentioning it to him, and, the Government having given me the permission to publish my work on Gunnery, he put the question to me, and asked me if I would show him the model. As I had permission to publish it, and of course it would be known to every one, I gave him one of the models; he was the Minister of War, and he declared that he had never seen or heard of any conical ball before; at the siege of Toulon the French invented an oblong ball, but he admitted it was tried and failed. About six months after this Colonel De Vigney took out a patent for a conical ball, because he found the conical ball was calculated for a rifle that he had invented some years previous; and it was evident the conical ball was not known in France, or the patent could not have been allowed. I forwarded this conical ball and shot to different members of the Government; they were sent down, I believe, to the "Excellent," to be tried. It was intended to be tried by an English musket, which they were made for; but I received a letter, stating that they would not try musket balls, I must send down 32-pounders. Now, I had no foundry, and, as a half-pay officer, was not at all disposed to set up one; and, therefore, they gave me the go-by, and there was an end of it. But a very short time after this, when our fleets were fitting out for the Baltic and Sebastopol, and I also sent them a plan to take Cronstadt, and how to fire concentrated broadsides; and I stated that I had tried these balls many years before, and on the coast of Spain. In 1812 I invented the sights combining the elevation and lines of sight in one focus. It was brought out seven years afterwards by an artillery officer, and is now called a military invention. This had wings, which were intended to prevent the shot wabbling in the gun, because a conical ball without wings, when it leaves the muzzle of the gun, would wabble. Mr. Lancaster took off the wings, and tried the conical ball before the Queen and Admiral Berkeley, at Spithead; and, in consequence of the wings being taken off, it diverged from the axle of the gun, and injured the lighthouse. Finding that was the case, they capsized the ball, and fired it so that when it left the gun it performed a somersault like Grimaldi.

This is a gun (*showing a model*) that I invented; it has two grooves only, and the conical ball has four. These two have zinc attached to them to fill up the grooves, the other merely fills up the bore of the gun. When the ball is sent home, it is turned out of the groove into a slot, and, on being discharged, offers the same resistance as an expansion ball. This is supposing you wish to have it rifled, because it is not decided yet whether you are to have it rifled or not. I load it from the breech, so that the men are not exposed to rifle firing through the ports; because, even in these iron vessels, they

* A model of Admiral Tayler's gun and conical shot may be seen in the Museum of the Institution.—ED.

must have their ports open occasionally. There is a small cone, and there is a slot inside; and, as you bring home the cartridge, this cone fits into the slot, and of course there is no escape of gas inside, and the men are not so exposed in loading the gun.

This is my fuse, which will answer every purpose. If a vessel is within a yard or at three miles, you have only to turn round the inner case, tighten the screw, and it will explode by time at 1, 2, 3 miles, and by concussion during its flight. There was a shell with a military fuse invented after this, and the Government took it up and adopted it. It was probably very good on shore, where you are firing with a fixed gun; but it is not at all adapted for the naval service, because you had to bore out the hole according to the distance, and then you handed it to the captain of the gun, and, by the time he has loaded, two steamers advancing towards each other or separating, would make a difference of a quarter of a mile, and, if you loaded one broadside, and the vessel came up to the stern of you and held off on the opposite side, it would remain in the gun and be no manner of use afterwards, and you could not draw it, therefore you must throw your shot away.

Admiral Halsted: How many years is it since you proposed that fuse?

Admiral Tayler: It was in 1840 I proposed conical balls, and the fuse I invented in 1854, I think.

Mr. Richards, of 2, Caroline Street, Bedford Square, then read a paper in which he recapitulated some of the desiderata of a naval gun, and an extract from the specification of a patent which professes to supply them.

Captain Fishbourne: Mr. Chairman, ladies, and gentlemen,—I am afraid I shall have to claim your indulgence, for the subject is important. Perhaps I may reverse somewhat the order as to the names of the persons to whom I allude. As Mr. Haddan did not offer any remarks on my paper, but merely referred to a very important subject—that is, the material of which guns should be made—I need not say anything in reference to his mode of rifling. The subject he brought forward is a very important one—I mean, the subject of metals; and the carrying out of his experiments may certainly lead to very satisfactory and economic results. It has been objected to Mr. Haddan, that he has been asked to make a large gun of the metal he referred to, and he has been unequal to do it. The answer, I dare say, many of you read in the *Times* of to-day (I have had no conversation with Mr. Haddan myself), that is, the impossibility of a private individual undertaking the works necessary for constructing guns of that description. Mr. Clay, in describing Mr. Horsfall's monster gun, told you of his difficulties in constructing it, and the greater facilities he has now, for constructing a gun of that kind; and I must say I do entirely sympathise with those various inventors who have had difficulties thrown in their way. There is boundless expense entered into, to try experiments that give no prospect, I think, of success; and experiments that do offer much prospect of success have not been carried out. Mr. Bashley Britten said little or nothing, either, as to the points that I raised with respect to his rifling. He brought forward an interesting subject, drawing a contrast between his guns and Sir William Armstrong's, in which he carried me with him entirely; and I sympathise with him, that he has not had the opportunies of trying it more effectually than he has had. Mr. Lancaster objected that the diagram did not exactly represent the degree of ovality that he now approves. Well, I was dealing with Lancasters as they are, not with Lancasters as they might be. All I can say is, I have no interest in the matter. I have no desire to set forward any one. I wanted to see the best gun; and it was partly because I was independent, and had no crotchet and no hobby to ride, that I was solicited to undertake this paper. If Mr. Lancaster will produce the best gun, the best rifled, and the best in all particulars, we shall hail it with joy. We want a best one, for we have not got it as yet. I thoroughly concur in what Mr. Lancaster said, when he was dwelling upon the question of cast-iron and wrought-iron guns, built-up guns of that description as shown in Plate I. fig. 2, that they are not fitted to undergo the rough work of ship guns. We all know that there are circumstances under which a ship, to save herself, is obliged to throw her guns overboard, and recover them again. I ask, in what condition those guns would be, if they were thrown overboard on rocky ground? Again, it often happens that they have to land the guns to fortify a point. It does not always happen that they have the facilities for hoisting them into the boats, and there is a great deal of rough work in dragging them over the cliffs. I want to know how it is to be done by that gun. Apart from the way in which Sir William Armstrong treated the subject, saying, "Well, it had stood," I may ask, what was my argument throughout my whole paper? It

was not as to what it had stood. I said it had not at all had the test it ought to have, or to which it must necessarily be put, if it is to give the high initial velocity we must have at all cost. There are two or three remarks made by Colonel Lefroy, which I did not answer at the time, and which I think it necessary and important to answer. For instance, Colonel Lefroy cited as proof, that Sir William Armstrong's gun was a suitable gun for naval service, that various Continental nations had adopted it; but he did not add that no naval power has adopted it. Russia, France and America have studiously avoided it. Then again, in respect to the manner in which Colonel Lefroy commented upon my paper—and I must also join with him, Sir William Armstrong—it was, I think, not fair. Thus, for instance, I am made to say on each occasion by them what I did not say, and they have answered what they have undertaken to say for me, rather than what I did say. Upon the subject of strength, Colonel Lefroy says, that as for my exception to the strength of the gun, why, it has proved itself sufficiently strong. Now, I did not say it was not strong. I did say it was strong; but what I did say was, that it was not strong enough to bear the high charges that it will have to bear, if it is to give us the initial velocity that is wanted. Those are two different things; and I particularly use in my paper this expression, that it would burst prematurely if it were subjected to these high charges. Why, Colonel Lefroy says so himself. "Oh," he says, "it will bear these charges, because we have tried it; but," he says, "you cannot continue it, because it will burst." Why, the proof of the pudding is in the eating, and he has given us an illustration of it. Then, with respect to stripping. He says that I stated, that if you attempted to give it the high initial velocity, it would strip, or that it would be dangerous to the gun—that it would not take the rifling, in fact. Now, Colonel Lefroy answers, that the guns have all been subjected to proof charges, and that their missiles have taken the rifling. What do we mean by rifling? and what do we mean by a rifle? We mean by a rifle that which performs the functions of a rifle, that is, it gives rotatory motion, and continues that rotatory motion, in order to get accuracy of fire. Now, I say, you may have any kind of rifling you please, or any kind of marks upon the missile; if it does not perform the functions of a rifle—that is to say, give and continue that rotatory motion, so as to establish precision—it is not a rifle practically. Such is the fact with respect to this. Table K represents a series of trials; mind, not high velocities, but such as is due to a very small increment of powder; for instance, from 1·75 lbs. to 1·50 lbs.; and the series is continued alternately, so that there can be no doubt of the accuracy; because, of course, with thirty rounds the piece gets hotter, and, if they did not alternate, it would not be fair. Now, what is the fact? We find that, just in proportion, every time as the higher charge is used, so it becomes less accurate. (See table.) The correctness of this may be gathered byan examination of the columns of Table K. headed "Charge" and "Mean Observed Deflection," contrasting column 9 with 15, which contains the results with an iron shot. So that there is a regular law established, that just in proportion as you increase the initial velocity, and increase the quantity of powder, so the rifling slips. It is evident here. [Pointing to a French shot and one of Mr. B. Britten's on the table.] Here is where the slip takes place. Anybody who looks at this, will see the slip here. On each side of these buttons there is the evidence of the slip. There is a series of these tables to prove what I say; and if it were not as I state, Sir William Armstrong is perfectly sensible of the value of initial velocity, and would have obtained initial velocity if he could have obtained it. He would have put more powder, if either the missile or the gun admitted it.

Then, as to the velocity. I do not say that they could not attain high velocity; I said, relatively as high as smooth-bore guns. Colonel Lefroy cited, in a very triumphant tone, "that they had got 1,746 feet from a rifle shot," whereas from an old round-shot 9-pounder they only got 1,613. Now, I might adopt the tactics of that fine old fellow Sir Richard Keats, when he got in between two enemies off Algeziras—he just backed astern, and let the two enemies fire into each other, for he had other work to undertake. If I turn to the *Times*, I find that Sir William Armstrong admits the whole question, that a smooth-bore has a greater initial velocity; and you remember last night he stated it again. So that what are we to say? Here is Colonel Lefroy, defending Sir William Armstrong, saying that his missile gets the higher velocity, and Sir William Armstrong, on the other hand, admits the whole question, and says that it is not so. Well, I think I need not say anything more about Colonel Lefroy.

Sir William Armstrong commenced his remarks by saying that I had no experiments, and he brought as his experiments just the record of *an* experiment. I would ask, what are all these but records of experiments? (Pointing to the various tables against the wall.)

TABLE K.

I.—Report of Ordnance Select Committee on Practice with Armstrong and Whitworth Guns, alluded to by the President, page 122.

3759 { 1671 B. Armstrong's B. L. 12-pr. Gun, *versus*
{ 1943 C. Whitworth's B. L. 12-pr. Gun.
With reference to *Minute* 3625. Report of Practice submitted.
Object,—To ascertain range and deflection of Whitworth's B. L. 12-pr. Gun, in comparison with Armstrong's 12-pr. Gun.

Date.	No. of Rounds.	Charge.	Elevation.	Armstrong's 12-pr. B. L. No. 6. Weight .... 8 cwt. 2 qrs. 11 lbs. Length .... 7 feet 6 inches.						Whitworth's 12-pr. B. L. No. 1. Weight .... 9 cwt. 3 qrs. 0 lbs. Length .... 8 feet 8 inches.					
				Range.			Mean diff. of Range.	Mean Observed Deflect.	Mean Time of Flight.	Range.			Mean diff. of Range.	Mean Observed Deflect.	Mean Time of Flight.
				Min.	Max.	Mean.				Min.	Max.	Mean.			
1861		lbs.	degs.	yds.	yds.	yds.	yds.	yds.	seconds.	yds.	yds.	yds.	yds.	yds.	seconds.
2nd April.	5	1·50	2	1108	1150	1130	12	4	3·4	1159	1223	1198	19	1⅓	3·5
"	"	1·75	"	1226	1307	1256	26	5	3·6	1266	1344	1289	28	1⅔	3·4
"	"	1·50	5	2128	2165	2146	11	9	6·8	2072	2486	2367	119	1⅓	6·9
"	"	1·75	"	2331	2399	2358	15	11	7·3	2335	2644	2471	97	1⅔	7 0
"	"	1·50	10	3512	3597	3568	24	12	9·8	4137	4318	4222	68	3	10·2
"	"	1·75	"	3866	3961	3908	41	17	12·9	4348	4449	4399	25	6⅔	13·1

Elevation by Quadrant. Guns mounted on Travelling Carriage, on Lieut.-Colonel Clerk's Platform.
Armstrong's Gun. Wads choked in Cartridge.—Whitworth's Gun. Powder and Wad contained in Tin Case.
Weight of Wad, 2 oz. 4 drms. Weight of Tin Case, 8 oz. 8 drms.

Is not Table K an experiment with the Armstrong and Whitworth? These are taken from Colonel Lefroy's own book. Every one of these are experiments, and they might have been multiplied to any number. And yet he says, I have no experiments; and, lo and behold you, he brings *one*. Then, with respect to the shunt gun, Sir William Armstrong objected to the diagrams, I had not given a fair measure of it, and so on. They were all measured by Mr. Vavaseur. He is a constructor of guns; he is perfectly conversant with them; and, so far from doing Sir William Armstrong any injustice, that given is the most favourable specimen of the large shunt family (see Plate I. fig. 9). If I were to have taken some of the earlier patterns, the windage would have been much larger; and, instead of Sir William Armstrong occupying the place he does in Table H, his name would have been considerably lower. When you consider that Sir William Armstrong was asked to speak on this occasion, and he asked for longer time; for there was such a multiplicity of figures that he really must get up figures, in order to be able to refute mine! If I was speaking upon my horn-book, I would not have to ask for time; and one would have thought that there was nothing here that he was not thoroughly conversant with. Sir William Armstrong affects to make light of the ricochet. Major Owen, R.A., in his lecture delivered here, does not do so, though he is favourable to rifled guns. Here is an extract from some information given before the House of Representatives in America: "Captain Dahlgren lays great stress on the certainty of large round projectiles *en ricochet*, which is most useful on water, and his 11-inch shells, weighing 135lbs., are certainly very formidable against wooden ships." I recollect an anecdote with respect to the value of ricochet. One of the steamers employed on the coast of Spain could not get in — I do not know precisely why, but she could not fire direct, because of an intervening point of land, upon the town; but she fired upon a cliff that was facing the town, and threw her shot very effectually into it. Now, I should like to know how Sir William Armstrong's shot would ricochet into that? They would not at all. Yet he attaches no value to the circumstance of ricochet! Then he seemed to throw a great deal of doubt upon this American experiment. Now, here is this work—Simpson on Gunnery—from which Table E is taken; anybody can read it; it is very interesting, and I think it bears evidence of the truth. The proof of it is, evident from his own gun. He wants to say this experiment is of no value, in order to disparage my statements with respect to the value of reducing the windage. But what is the fact, both with respect to Mr. Bashley Britten's gun and with respect to his? Why, because they reduce the windage, or because they reduce it so as to destroy the windage altogether, they produce great results with small charges. Why, that is just what takes place here. Either Sir William Armstrong does not produce results that he says he does, with small charges—there is not that extreme tension upon his gun, by explosion in his gun, that he states there is—or else this table is true. Then, if it is true, it is monstrous to draw a comparison between old guns with very large windage, and his guns that have no windage at all. He went into a long argument last night, to prove that it was a question of weight, not of friction. Now, here are some experiments that prove the very reverse. If it was the weight that was the cause of the higher initial velocity, then, instead of getting 1,809 feet initial velocity with the 51-lb. 8-inch shell, and 1,579 with the 66-lb. shot, these figures would be reversed (see table B). He says that the effect of the weight retaining the shot in the gun so much longer increases the elasticity of the powder to such a degree that it overcomes and gets a greater result. Why is it not shown so here? Here is the greater weight, and here is the less initial velocity. The fact is, that there *is* friction, by which, and by giving rotatory motion, power is absorbed, as any one who believes in mechanical laws must admit.

Sir William Armstrong undertakes to say that I said that the trajectory in this diagram, (Plate I. fig. 13), was that of his shot—of his ball. I did not say so. Here is my paper, in which what I did say is written. I simply supposed the case of a shot that would travel a distance of 600 yards in one second; and I supposed the case of another shot with less initial velocity, or half the initial velocity, that would require two seconds to travel the same distance. Then I drew *that* as an illustration of what would be the result. I, of course, gave Table C *a*, Appendix, also; but there I gave the actual quantities, and pointed to the actual quantities. The lines (see Table) represent the point-blank ranges of these respective guns, as given by the authorities. I am not in the least responsible for them. The table was prepared by Mr. Clay, and it must be taken for what it is worth. The principle is just the same. If, on the contrary, instead of taking only one second and two seconds, where the difference between fall by gravity is the difference between 16 and 64, I had taken the difference

between two and three seconds, there the difference would have been greater, because it would have been the difference between 64 and 144 feet. Now, Sir William Armstrong repeats a statement, and I must say it is deserving of comment, and of strong comment. We can understand a person at a meeting, getting up and speaking hastily, and extemporally, using an expression that is not quite to the point, or giving a fact that is not relevant; but when Sir William Armstrong asks for time, and when a fact such as it was—for it was a fact of its kind, but not a relevant fact—was given by Colonel Lefroy with respect to the rifle as compared with the round shot, and Sir William Armstrong hears that, and then twenty-four hours afterwards repeats that, I say it is deserving of comment. Now, what are the facts concerning that? The meeting was led to suppose that this was an accurate rifle projectile, such as is used in ordinary service. It was not such. Here is the paragraph which appears in the paper, "It has been the fashion of late, on the part of those who have studied gunnery, to assert that the initial velocity imparted to a shot from a rifled cannon is less than that which would be derived from a smooth-bore gun. Sir William Armstrong joined issue on this point, and, in order to settle the matter, he, on the day alluded to, loaded a 12-pounder, on his principle, with a shell weighing 8 lbs. with a 2 lb. charge of powder, and the initial velocity obtained was 1,740 feet. A 9-pounder smooth-bore was then loaded with a shot of 9 lbs. and 2¼ lbs. of powder, and the initial velocity amounted only to 1,613 feet."* The first position is this. I stated that elongated rifle balls could not be projected with the same initial velocity as round balls, and I stated the reason. The greater weight, and the wings, or rifling, would prevent the one from being projected with the same velocity as the other. Now, here is not an ordinary rifle projectile. His ordinary rifle projectile for this piece is 11lb. 12oz. He reduces that down to 8 pounds. How does he do it? He must cut it in various ways. He must cut it shorter; and I have no doubt he reduced the lead. He reduced a great deal of the friction; and in fact he reduced it as far as possible to the conditions of a round ball; and then he fires it against a round ball, out of an old 9-pounder, with all its windage, while he reduced all the friction of his own.

Mr. G. Rendel: No, no.

Captain Fishbourne: Well, comparatively.

Mr. G. Rendel: The shot was not reduced in any way.

Captain Fishbourne: Are you prepared to say that?

Mr. G. Rendel: Certainly.

Captain Fishbourne: Perhaps you will explain afterwards how it was?

Mr. G. Rendel: I have nothing to explain, except that the shot was not reduced.

Captain Fishbourne: Then what was it, may I ask?

Mr. G. Rendel: You say the shot was turned down.

Captain Fishbourne: Perhaps you will explain. I am not anxious to mislead in any way. Perhaps you will kindly explain what was done.

Mr. G. Rendel: I merely say that the shot was not reduced.

Captain Fishbourne: I say it was reduced from 11lbs. 12oz. to 8lbs. Will you describe how it was reduced?

Mr. G. Rendel: I will, if you will allow me. You stated that the lead was reduced at the back, to take away all the friction. Such was not the case.

Captain Fishbourne: That was my impression.

Commander Scott: It was a specially prepared projectile, not the ordinary one. Perhaps you will state what it was. Let us have the fact.

Mr. G. Rendel: I merely wished to correct one important statement that was likely to mislead the meeting.

Captain Fishbourne: Will you state the whole facts? Because that is really the point to be arrived at. I do not want to mislead the meeting.

Commander Scott: Describe the projectile.

Mr. G. Rendel: I am not in a position to describe the whole facts, but I hear things stated that are not correct. I understand you to say that the lead is turned down at the base of the shot, with the view of reducing the shot to the condition of a shot fired from a smooth-bore gun. I believe that such is not the case, and, as it is an important feature in the experiment, I think it right to say so.

Captain Fishbourne: You reduced the weight.

Mr. G. Rendel: I know nothing of the weight. I know there is a 9-pounder shot fired from a light 12-pounder gun. There is such a shot as a 9-pounder, and I believe

* See Army and Navy Gazette, May 17, 1862.

that must have been the one used in the experiment, not a special shot constructed for the purpose. You would lead the meeting to suppose that a special shot was made for this experiment, and that I call in question.

Admiral Halsted: When you use the term "turned down," do you use it in the sense of reducing the diameter, paring down?

Mr. G. Rendel: I am answering Captain Fishbourne.

Captain Fishbourne: I understand it was a 12-pounder gun, and not a 9-pounder, that you spoke of.

Mr. G. Rendel: It is the same calibre; and the size of the gun is stated.

Captain Fishbourne: Gentlemen, I am not in a position to tell you. What I say is this, that the meeting was led to believe that this was an ordinary service projectile; that an elongated rifle shot was projected, and produced the velocity of 1,740 feet. Neither did Colonel Lefroy nor Sir William Armstrong say anything about the reduction of the weight at all. Now, what I complain of is this, that in a public meeting of this sort, men in the public service, upon a public question, with one of Her Majesty's ministers in the chair, should undertake to get up and state half the facts.

Commander Scott: As the meeting has been interrupted on this occasion, I may claim from the Chairman permission to say this, that the 9-pounder is served out as a 9-pounder, and never mentioned as a 12-pounder. The 12-pounder gun is issued as a 12-pounder. I never heard a 9-pounder called a 12-pounder in my life, and I do not know that it has ever been.

Mr. G. Rendel: The 9-pounder is simply a 12-pounder shortened.

Commander Scott: It is a different gun which has been supplied, in consequence of the other gun being too heavy for the horse artillery. I know it quite as well as you do. It is a 9-pounder.

Captain Fishbourne: What I contend is, that under any circumstances it is a one-sided experiment, and I want to know why one-sided experiments are to be made; and I want to know why, after one-sided experiments are made, they are given publicity to in the public press, when experiments that are of immense value and immense importance, that make altogether in the opposite direction, are kept covered up. Sir William Armstrong affected to throw discredit and doubt upon Table E. I had a great many more facts of this description. I did not want to crowd them upon the meeting. The first part of Table G was in the *Times* newspaper; others were taken from measurement at Shoeburyness and the official reports, and Sir William Armstrong affects to say that these are not accurate. The principle on which the numbers given in Table A, and headed comparative force of blow, are calculated is the admitted principle, that the resistances of iron plates are as the squares of their thicknesses. These figures are only inverting the operation, and taking the indentation, and squaring that, as giving a measure of the force of the blow which made those indentations.

There is another fact that I do think Colonel Lefroy and Sir William Armstrong, more especially Sir William Armstrong, when he was talking upon this very important question, should have told us at the same time, and that was a fact which he kept quietly from us; and certainly, by what he said, he led us to believe that there was no such fact in existence. It is this: that from a smooth-bore gun, with a 150 lb. shot, 2,000 feet velocity was obtained. Now, I dare say most of the persons present do not know that such an experiment has been made at all, and I do say it is one-sided for Colonel Lefroy and Sir William Armstrong to speak about the wonderful velocity of 1,740 feet got from his gun, and to speak of it as the greatest velocity. I do not actually use his words, but certainly that was the impression left behind, that it was greater velocity than was obtained from the smooth bore, when we have the smooth bore giving 2,000 feet instead of 1,740. It is quite true, there was a large quantity of powder, but it was a smooth bore. That is the question at issue. His rifle guns will not bear the amount of powder that was fired out of these smooth-bore guns; and the whole question turns upon this.

Admiral Halsted: Allow me to make one remark. The charges from which these initial velocities were got, were all fired by galvanic battery; and in the case of the 80 lb. and 90 lb. charges, they were fired from two different places. The length of the cartridge amounted to about two feet, and two wires were put in, with about the space of eight inches between them. The cartridge was therefore divided into three parts. That is how that initial velocity was obtained. Otherwise it was utterly impossible for a gun of that description to have burned 60, 70, 80, or 90 pounds of powder during the period of the passage of the shot from the breech to the muzzle. Therefore, all these velocities are perfectly abnormal.

Captain FISHBOURNE: I think, Admiral, you are a little beyond the book; because Sir Howard Douglas gives an initial velocity of 2,200 feet.

Admiral HALSTED: I merely stated how it was obtained.

Captain FISHBOURNE: But you went beyond, and said that was a velocity that was purely abnormal.

Admiral HALSTED: I meant that mode of firing the cartridge was perfectly abnormal. It is usually fired from the touch-hole.

Captain FISHBOURNE: I beg your pardon. It just comes to this—that, notwithstanding the objections which Sir William Armstrong undertook to refute, I am not aware that the audience will say that he has refuted a single fact or a single statement that I have brought forward; I do not know that he has undertaken to do so directly; he has cast, as I said before, a doubt upon Table E; but there it is. Here is the work:* the man will speak for himself. Any person who reads this book will be, I am sure, satisfied as to the character of it; and it is really a representation of facts, and it is just as much an experiment, and I say a far more accurate experiment, than that, in which 1,740 feet initial velocity was obtained; and I think you will observe that Sir William Armstrong acknowledged that in the end we must have smooth bores for ship's broadside guns. I am quite satisfied of it myself. I am quite satisfied that it is not with lead-coated projectiles, or lead in any shape on projectiles, that you can at all get the initial velocity that will suit for ship guns, for breaching purposes, at short distances; and therefore if you cannot from strong missiles of this description [pointing to an iron shot with iron bearings] get the initial velocity you want, you have no alternative but to have smooth-bore guns; and I think it is quite evident that this is the conclusion Sir William Armstrong has come to himself; but I do say, and I do feel—and I think any persons who consider about it, will agree with me—that, seeing the number of crotchets Sir William Armstrong has had upon the subject, it is hardly fair to leave our service any longer at the mercy of his further crotchets. I do feel most strongly that the question ought to be an open one, and that experiments by other people ought to be admitted, that there should be an independent body to determine what the experiments should be, and to see them carried out. Why, what is the fact? Here we have these old service guns, that have done us good service, condemned by wholesale, just upon the mere fiat, that "this will not do," or "that will not do;" in the same style in which he condemns this, "Oh! this is impossible, it cannot be; I give you no reason for it." As if we were all children that we must accept his dicta, just because he chooses to say it. Why, really it is quite sad. A criminal, if he only goes to the judge *in formâ pauperis*, has a counsel appointed to defend him, but here these poor smooth-bore guns, with all their disadvantages, have the judges and jury and counsel and spectators all against them. No wonder they are condemned and thrown out of court. I do say the country would never get better worth for a fee, than if it were to appoint a person or suitable persons to watch these experiments and see that they are proper experiments and properly tried. Would any one believe that Sir William Armstrong, who demonstrates to you, and writes to the *Times* newspaper on, the importance of initial velocity, should systematically neglect it? There is not one experiment that is made, except those lately, in which the grand object has been to get greater initial velocity. Every experiment has been "how not to do it."

I am sorry I have troubled you so long on the matter. I have hardly made it as clear as I should like to have done, because it is a large subject and it is not my subject. There are many others who would have undertaken the subject much better, and done much better by it; but it might have been said that they had a crotchet, or a hobby to ride. I have none.

The CHAIRMAN: Having now brought this discussion on the best naval guns to a conclusion, I may mention that the Council have before them the subject of the best metal for a naval gun, on which they hope to elicit equally valuable information as they have done on the present occasion. As soon as it is arranged, they will advertise when the discussion is to take place.

A vote of thanks was passed to Captain FISHBOURNE, for his paper, and the proceedings terminated.

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* Ordnance and Naval Gunnery. By Lieutenant Simpson, U.S. Navy.

Since the above discussion took place a 9-pounder Armstrong segment shell and a 12-pounder Armstrong proof shot have been deposited at the Royal United Service Institution, by Colonel Lefroy, R.A., with the undermentioned description, to illustrate his remarks:—

"1.—9-pounder Armstrong segment shell (weighing without fuse or bursting charge 8¼lbs.) This specimen has been reduced to 8lbs. by removing 4oz. of the inside metal, and is one of those prepared for a determination of the initial velocity of an Armstrong shot fired with a charge of one-fourth its weight, May, 1862.

"For charge 2lbs., the mean velocity was:—

1,662 feet per second with A_4 powder.
1,746 feet ditto with 2_4 A powder.*

2.—12-pounder Armstrong proof shot, fired with a charge of one-fourth its weight. Exhibited to show that shot fired with this charge take the rifling.—Ed.

* 2 A_4 powder has a much larger grain than A_4.

We are requested by Captain Fishbourne to add the following explanatory note:—

"Understanding that Colonel Lefroy has sent an Armstrong 12-pounder shot, and a 9-pounder segment shell, reduced to 8 lbs. to be deposited in the Institution to prove the correctness of his statements, I beg to add that I did not question his facts, but their relevancy to my statements.

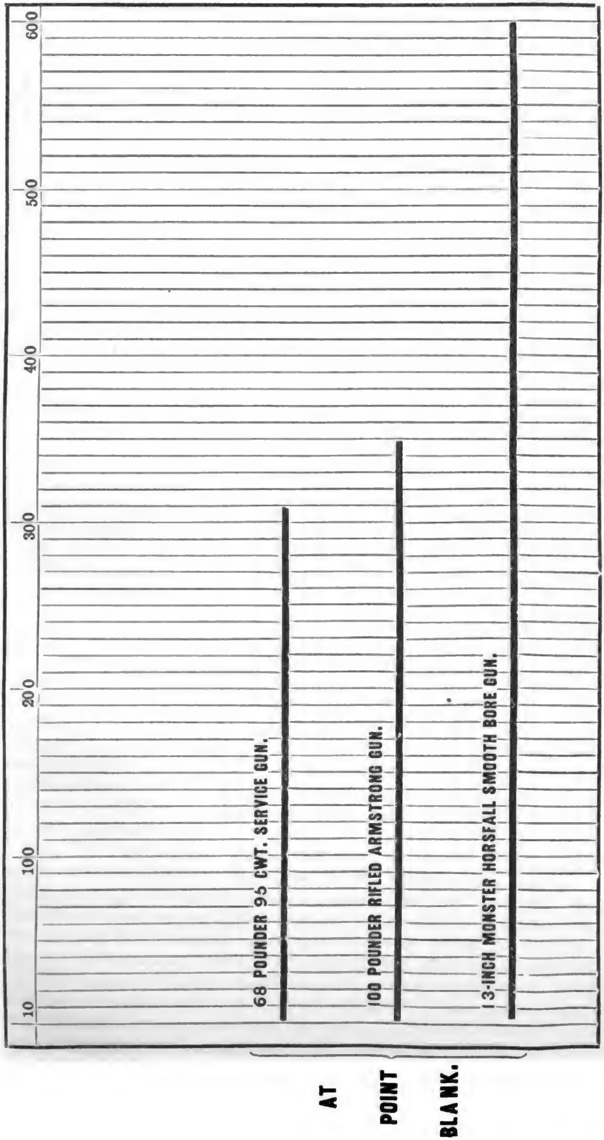
"I did not say that under exceptional circumstances, and with velocity greater than usual, the Armstrong shot would not take the rifling; my statement was, that if elongated lead-coated shot were driven up to the maximum velocities obtainable with spherical shot, the former would slip, or burst the guns if the coating were hardened, and I especially alluded to heavy naval guns, which are fired with high charges for breaching iron plates.

"The experiment with the 8 lb. shell was irrelevant, as I did not say that a high velocity could not be given to an elongated shot under any circumstances; but that to an elongated shot could not be given a velocity equal to that given to a spherical shot under the conditions stated in my paper, in which I dwelt on the necessity for heavy guns and high charges for ship purposes.

"The following would have been relevant to my paper, and would have been a useful and a scientific experiment:

"A spherical shot with the smallest practical windage fired from a gun of equal diameter, and precisely similar to the 110-pounder (but with a smooth bore), and with a charge that would bring equal tension upon it with that which the 110-pounder multi-groove is subjected to, when fired with the highest charge it will *safely* bear."—Ed.

TABLE Ca.—RANGES IN YARDS.



Ranges of 68-pounder and 100-pounder taken from the Handbook for Field Service, 1862.
The range of the Horsfall 13-inch Gun taken from the official Report to the War Office dated 5th February, 1857.
Height of axis of bore above the plane, the 68-pounder gun not stated.
" " 100-pounder Armstrong 17ft.
" " 13-inch Horsfall 20ft.

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LECTURES.

Friday, February 14th, 1862.
Captain E. G. FISHBOURNE, R.N., C.B. in the Chair.

IRON AND STEEL AS MATERIALS FOR RIFLED CANNON.

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If the value of a material were to be estimated by the place which it occupies in the world, in regard to its usefulness for serving the multifarious purposes of mankind, then to the class of metals known as iron and steel in their many modifications must be ascribed an importance and position superior to any of the other mineral substances which have been placed at our disposal.

Iron, including steel, is the great staple article of Britain, and is the chief agent by means of which this country has been enabled to maintain the prominence she holds among the other nations.

In this country alone above five million tons are produced annually; and the increasing applications of those materials, which we daily see going on around us in every branch of the arts of peace, as also their extensive usefulness in connection with the art of war, render it highly necessary that every intelligent individual should have some acquaintance with the leading peculiarities of those substances; and the object of the present lecture is—

1st. To point out generally the nature and the leading characteristics of those materials; and

2nd. To consider their comparative fitness for one of the purposes to which they are applied as munitions of war, namely, rifled cannon.

As there is no other subject in connection with the wide range of practical mechanism engaging more attention at the present time than the one now under consideration, and which is already so well known in many of its details, it cannot be expected that much additional light will be thrown upon it in the present instance, or that any claim for originality can now be made; still it is to be hoped that the first part of the lecture may be useful to some, and that the facts which have come out under my own observation and experiments, which are referred to in the latter part, may be instructive to all.

Although iron is frequently referred to in the Old Testament Scriptures, yet we cannot find that it was extensively used until a much later period; the hindrance to its introduction probably arising from the extreme difficulty experienced in separating it from the earthy matters with which it is found in the condition of "iron ore."

The ores of iron are found extensively scattered all over the world, yet, comparatively speaking, few are now considered as fitted for the purposes of the iron-maker; questions of quality, means of effecting reduction, and other commercial questions, chiefly determine their value.

In Sweden and in some other countries iron ore is found in solid rocks, forming veins in the granite of enormous thickness, such ore being comparatively pure. This ore is supposed to be of volcanic origin, and, being generally in conjunction with igneous rocks, it in all probability at some remote period was belched out from the molten matter within the globe.

But in this country most of our iron is found mixed up with indurated clay or mud, in lumps or nodules; and it is supposed that these lumps are the mud of such veins of volcanic iron ore ground down by the geological floods of an early era.

These lumps are generally found in beds, and frequently just above and under and alternating with the seams of coal by means of which they are to be smelted, and also in close proximity to the refractory material called fire-clay, which is so valuable an agent in their reduction.

Previous to the smelting process, by which the iron is separated from the earthy matter, it is found necessary to subject the ore to a preliminary process of calcining, or, as it is commonly termed, roasting, which is simply a subjecting of the ore to a continuous dull red-heat for a considerable period in order to drive off the foreign matters which are injurious to the quality of the iron, and also to produce a greater degree of oxidation, as well as to open up the ore and render the smelting process more easily effected.

The degree of heat employed in roasting, the period of time required, and the description of kiln or oven which is used, depend entirely on the nature of the particular ore, and are found to differ in almost every locality: in all the object is the same, namely, to keep the ore at such a temperature and for such a length of time as will be sufficient to expel the injurious gases; those conditions of procedure in the great majority of cases being derived from experience rather than from any chemical knowledge of the changes to be effected.

Up to this stage the ore has but little resemblance to the valuable metal which it contains, and the first great step in advance is to eliminate the earthy matter and set the iron free.

This is effected in different ways; but the general method is to put the ore and fuel into the furnace together, then to generate an intense heat by means of a strong blast of wind, until the refractory ore is overcome and the iron begins to melt.

Without some other agent to assist, the process of separation would be very imperfectly accomplished: it is found necessary to employ what is termed a flux. This flux material is also thrown into the furnace along with the ore and fuel, and the chief object of the flux is to unite with the earthy matter and set free the iron.

With argillaceous or clay ore a calcareous flux, generally limestone, is

used; with a calcareous ore an argillaceous flux is employed, or, what is better, a mixture of both descriptions of ore in due proportion.

Under the high temperature within the furnace, the two earthy substances assimilate and form the glassy slag or scoria, which, being lighter, floats upon the liquid iron at the lower part of the furnace, and runs off by an opening left on purpose; while the iron (when a sufficient quantity is collected) is run out upon the floor into the pig-iron of commerce.

From the circumstance that the melting iron is in such intimate contact with the fuel, and from having to pass through it like water through a filter, the quality of the iron is necessarily much affected by the nature of the fuel, and as it so happens that the presence of sulphur, phosphorus, and other impurities is found to affect the conditions of strength and other properties of the iron, those descriptions of iron that are made with the purest mineral fuel are the best, supposing other conditions to be the same, and best of all is the iron smelted with the charcoal from wood, which is obviously more free from those injurious properties that belong, more or less, to all mineral fuel used in the iron manufacture on a large scale, with which I am acquainted.

By subjecting mineral coal to the process of coking, it is purified to a considerable extent, still the iron which is made even with coke is not of such high quality as that made with the still purer fuel of wood charcoal.

It will thus be seen that at the very threshold of the manufacture there are causes in operation that seriously affect both the quality and the cost; and that, although in the manufacture of ordnance, a material of the very best description is the desideratum, still in the wide range of the arts there is, at the same time, a demand for every quality. It thus happens, and that to a great extent, that price rather than excellence is the predominating influence that determines the manufacture.

Iron may be divided into three great classes; these are known as cast and wrought iron and steel; indeed, for all practical purposes, they may be looked upon as three distinct metals.

Cast iron is the material as it runs from the first process of the smelting furnace, and is that from which both wrought iron and steel are made.

During the smelting process, the iron has absorbed a considerable quantity of carbon, as well as still retaining several other ingredients and original impurities, the presence of which renders cast iron capable of being melted and remelted a number of times, and used for the various purposes of the iron-founder, and the metal is sufficiently liquid to admit of being poured into moulds of any form with the greatest facility; hence, if cast iron had the toughness or strength, and the other good qualities of either of the other modifications of this metal, namely, wrought iron or steel, it would necessarily have the preference, not only on account of its cheapness, but also from the great readiness with which it can be poured into almost any variety of intricate outline, at a small expenditure of fuel, wages, or plant.

Cast iron, when considered as a material for the iron-founder of general articles, is mostly affected by the proportion of carbon which is present.

The carbon renders the iron more liquid when in the fluid state, and softer when in the solid condition, at the same time it is not quite so strong in regard to its tenacity, although possessed of more toughness

than iron containing a less quantity of carbon; hence the founder is to a great extent guided in the selection of pig-iron for particular articles by the quality of the compound.

For castings where great strength is aimed at, considerable judgment is necessary in the selection of a mixture that will secure all the conditions of softness or hardness, closeness of the grain, and that degree of toughness and strength, which may be necessary.

There are many instances on record of cast iron having shown an amazing amount of strength, toughness, and general endurance, both as guns and in other constructions; still, at the best, it is uncertain, and, as will be seen hereafter, it is not strong, and is proverbially treacherous to depend upon, as it gives no warning before rupture; and hence the time has arrived when, for ordnance especially, it seems about to give place to a better material, either wrought iron or steel, or perhaps a combination of both.

The malleable, ductile, tough, and fibrous material termed wrought iron, which is so extensively used by the smith for every branch of art, is made directly from cast iron by an elimination from that compound of its carbon, sulphur, silicium, phosphorus, and other impurities, by a process of oxidation.

This purification of cast iron produces a material with entirely different characteristics; it becomes much stronger, has greater toughness, is highly infusible; it loses the property of becoming liquid, and is therefore unfitted for the founder's purposes. At the same time, however, it acquires another property, almost equally valuable, for, when brought to a high temperature, it acquires a viscous or sticky character, so that if different pieces in this condition are brought together, they adhere, and if a blow is given or pressure applied, the separate pieces are made to adhere permanently.

This remarkable property is termed welding, and is the basis of the art of forging, as practised by the smith.

The conversion of cast into wrought iron is effected in different ways, although the same principle is adopted in all, namely, to burn out the silicium and carbon.

One arrangement is, to drive off these matters by fusing with charcoal while a hot blast is playing on the liquid mass; but the more usual plan in this country is to subject the liquid to the well-known process of puddling. The cast iron is melted in a furnace in which a hot oxidising flame is brought to bear upon the fluid; by means of iron tools the mass is moved and stirred and turned over in every direction so as to expose every portion of the iron, in turn, to the influence of the flame.

Under this influence it gradually loses its fluidity, and acquires the viscous or sticky property. It is then parted into lumps of a size suitable for manipulation; each lump is afterwards subjected to a still further process of purification, and one which is dependent on another principle for its efficiency.

The lump of viscous iron may now be compared to a very dirty sponge that requires to be several times wetted and wrung in order to make it pure and clean.

On its removal from the puddling furnace this lump of viscous iron matter, like a dirty sponge, is put under a heavy hammer or other

apparatus, the blows or squeezing of which drive off the impurities, and the mass is worked out still further by means of rolls into a long bar of coarse and dirty iron, unfit for the smith, and which is afterwards cut into short pieces. These pieces are piled up into a bundle, and are again put into a furnace and subjected to another heating; the iron is again brought to the welding state for another washing, and is again subjected to another beating from the steam hammer, and a squeezing from the rolls, all which still further improve the purity and the quality of the iron bar.

For the production of the better descriptions of iron, this process of purification, of cutting up, re-welding, and hammering or rolling, is repeated several times until the proper quality is attained. Of course such treatment, while it improves the material, also increases the cost in a still greater proportion.

Even after the best treatment, the wrought iron of commerce is not chemically pure, although its combination with the grosser impurities does not seem to be of that intimate character that exists in cast iron. It still contains carbon, silicium, and other matters, which fill up the minute vacant spaces between the fibres which compose the structure of the bar.

In consequence of the great affinity which iron has for sulphur, phosphorus, and other impurities that affect its quality, the quality of wrought iron is much dependent on the character of the fuel employed in its manufacture; the purer the coal the better is the iron, and hence that which is made with wood-charcoal is necessarily the purest and best, although, at the same time, it is most expensive.

The quality of wrought iron is also greatly dependent on the original selection of the mixtures of cast iron for puddling, and on the care, skill, and close attention which are brought to bear upon all its successive stages; hence iron comes to differ as much in its qualities and properties as any two materials of the same class could be expected to be capable of doing, and more so than that of any other similar substances with which I am acquainted.

This difference, however, is only detected when high conditions are aimed at, then close observation discloses innumerable shades of quality, that escape the observation of the majority of workers in iron, who use the material for purposes where the object required is easily secured.

The conversion of cast into wrought iron by the removal of carbon and silicium completely changes the characteristics of the material. It has lost the brittle property; it now yields and stretches before it breaks; the permanent yielding point is now higher than the former breaking point, and the breaking point is double that of the yielding point.

These are all strong conditions in its favour, but at the same time it has many serious defects.

It is difficult to produce in large masses that are perfectly sound throughout; the smith or forgeman has little control or authority over its behaviour when in the welding furnace, and hence it is extremely difficult to produce large forgings perfectly sound, even with the best treatment; there is, therefore, still great room for improvement, so as to ensure a perfectly homogeneous mass, possessing all the good properties of the malleable, welding, tough material, and which, at the same time, shall be free from its numerous defects, veins, and unsoundness; yet it is but just to

add, that, with all its many defects, there is no material at the present time which can be so implicitly relied upon and trusted with so much security against fracture from sudden vibration, as a piece of good sound wrought iron.

The material called steel is an intermediate compound between cast iron and the former material of wrought iron.

Steel is comparatively a pure iron, containing a small per-centage of carbon with some other substance in combination, which is rather obscure, and regarding which there is considerable difference of opinion. This combination gives the material some very peculiar characteristics of its own, and is entirely different in character from either of the metals out of which it is made.

Steel can either be made from wrought iron or from cast iron.

The latter arrangement is the cheapest process, but the former method affords the most certain results at the present time, and that is the system chiefly resorted to in making the finer qualities of steel.

To make good steel of high quality, a bar of pure wrought iron is selected, mostly Swedish, which has been made with charcoal in all its previous stages. The iron bars are put into a fire-brick chest, along with a quantity of charcoal powder; every part of the bar being surrounded with the carbon, the air being excluded, the whole is made white-hot, and kept in that condition for several days, generally about a week, according to the amount of conversion that is required. During this period the pure white-hot iron imbibes a new property from the charcoal into its own nature.

A chemical action takes place, and the wrought iron has been thus gradually turned into steel. Such steel, however, is very imperfect. The defects are chiefly owing to its local irregularities of conversion, for although the entire mass of the bar may have had the proper quantity of carbon put into it, yet it is found to be much improved through mixing the particles, either by welding several bars together into one bar, or even the mere working of a single bar under the hammer has the effect of equalizing and greatly improving the quality.

The most effectual way, however, of obtaining a thorough mixture of the particles is to break the original steel bars into small pieces, then to melt them together in a crucible into liquid steel, and then to mix and pour this metal into an ingot, which, when solid, is then drawn into a bar of steel of the required dimensions.

By this means of putting carbon into pure iron, cast steel is produced, which is the finest in quality of any of the varieties of this valuable metal. But good passable steel can be made directly from cast iron, simply by not carrying the puddling process on to the full extent of wrought iron. Such material is called puddled steel; and although at the present time it is not equal in quality to that which is made in the other way, still it is very much cheaper, and when more experience has been gained so as to determine the best descriptions of cast iron that are suitable for this particular process, as also the precise period when to discontinue the puddling operation, so as to leave the proper quantity of carbon in the metal, there can be no doubt but that such cheap steel will be extremely valuable for many purposes, seeing that puddled steel is malleable, and has even a higher tenacity than wrought iron.

A very fine material is now produced extensively by breaking up the

rough bars of puddled steel and melting them into a cast steel, and which for many purposes is found equal to ordinary cast steel as made from Swedish iron; so far as I am aware, however, it is not so good for edge tools.

Good steel can be made in a still more summary manner by means of the "Bessemer process." The crude cast iron, when in a melted state, is poured into a large refractory vessel previously heated, and a strong blast of air is forced through the fluid, producing a violent agitation.

The silicium and carbon in the iron unite with the oxygen in the air, and are driven off from the metal, until the remaining mass is almost pure wrought iron.

There is then added to the iron (in order to make it steel) a definite quantity of carbon; it is introduced in the condition of liquid cast-iron, of known mixture and quality; the whole is then thoroughly mixed, and the entire process is completed in about half an hour from the time of first pouring in the cast iron to the final running out of the steel into moulds or ingots.

By the Bessemer process large masses of steel can be made more easily than by any other method yet introduced, and apparently at less cost, and there is no doubt that in time this process will produce uniform quality.

Steel in all its combinations is a most valuable metal; in its ordinary state it is closer in structure, has greater power of resisting compression, and possesses a higher tenacity than wrought iron, even of the best quality, and as such it commends itself to the engineer for the manufacture of the best class of articles, notwithstanding its greater cost, and the still greater expense which has to be incurred in its fabrication into the requisite forms. But it has another property, which causes it to transcend in value all other metals, namely, the capability of being tempered to any degree of hardness or softness.

The discovery of the fact that a piece of soft steel, when heated, and then suddenly cooled, no matter by what means, assumes a hardness approaching that of the diamond, is perhaps the most important of any in connexion with the whole range of metals, and has been of the greatest service to mankind.

In addition to this property of hardening, when the said hard substance is exposed to a gentle heat, it gradually begins to give up a portion of its hardness, until at length it loses it altogether; and as it so happens that at the same time that the hardness is gradually departing, a definite change of colour of the surface of the steel accompanies the softening process, this change of hue becomes a correct measure of the change in hardness, and thus the precise degree of hardness or temper that may be required for any purpose can be attained with great certainty and uniformity.

Steel, wrought iron, and cast iron can all be rendered softer and less brittle by means of the annealing process, which is simply causing the materials to be made red hot, then keeping them in that state for a short time, and afterwards allowing the whole to cool down very slowly, so that every part may cool at a uniform rate, and no part or particle be under any restraint from premature withdrawal of heat, thus causing local contraction and hardness.

By prolonging the period of cooling, a mass of steel comparatively

brittle acquires the character of toughness in a remarkable degree, and this process of annealing now plays an important part in all modern efforts to use steel either for guns or armour plates, or for anything exposed to jar or sudden vibration.

Such is a brief description of the metals—cast iron, wrought iron, and steel—which are now attracting so much attention in the world, more especially in regard to their adaptation and application as materials for war purposes, and which are now to be shortly considered in regard to their several and relative fitness for the manufacture of rifled cannon of large calibre.

The numerous and repeated failures that have occurred, and are still occurring, in the application of iron and steel for the above purpose during the past few years, and even at the present time, clearly show, that that which is wanted, necessarily implies some high conditions which are very difficult to secure, and which appear all the more difficult to those who are the most concerned, and whose province it is to endeavour to obtain them.

For small arms, and even for cannon of the smaller class, there is not much trouble experienced in applying almost any good material, whether bronze, iron, or steel; but in dealing with heavy breech-loading guns of large calibre, elements of weakness are brought into view which are exceedingly difficult to provide for and meet successfully.

The severe proof to which rifled guns are now subjected, consisting of seven rounds, with two of the charges of gunpowder being equal to one quarter of the weight of the projectile, is found to thoroughly search and try their soundness, both in regard to the materials and the workmanship, and is sure to develope any seriously defective part, if such exists; but the mere withstanding of the proof rounds is found not even sufficient to thoroughly test the perfect soundness of a gun.

In wrought-iron guns, which have resisted proof successfully, minor defects will sometimes appear after a number of ordinary service rounds; such defects have required a repetition of charges to bring them out into view for examination, each successive round acting like the blow of an enormous sledge-hammer, and gradually producing an alteration of form in the bore or in other parts of the structure.

Again, there are some of the steel class of materials that have been tried, apparently with great success, which have not only stood proof, but have been fired a great number of times, and yet prematurely have been ruptured; the effect of the firing seems to derange the crystallization, and to have been like the repeated blows of the hammer driving home the wedge, until a separation of the particles is effected.

It is also found, however paradoxical it may appear, that the strongest material after a certain point, whether of wrought iron or steel, makes the weakest gun; that wrought iron as it approaches the character of steel, while becoming better adapted in several respects, is getting all the worse in other respects still more important; and that when steel is annealed and otherwise treated, until it seems to be losing all the good qualities for which it is so celebrated, that then it is becoming all the better adapted for the sudden jar and vibration of a gun, but at the same time it is losing some of those good qualities which chiefly recommend it as a competitor with wrought iron for the construction of rifled cannon.

So far as my present experience goes, we are still in want of the proper, the perfect material for the interior of the bores of large guns, a material that will afford bores invariably sound and perfect, and which will remain so in the same manner as an ordinary musket barrel, and which at the same time shall be as safe against bursting, as guns built up of wrought iron on Sir William Armstrong's principle, which in that respect may be considered perfect, and as fulfilling all that is or can be desired or reasonably expected.

The extraordinary effect that is sometimes produced in the bores of rifled guns made of any description of metal which will not be in danger of bursting, from its hardness, is much greater than is generally supposed, and is only known to those who are more immediately concerned, ordinary bronze gun-metal being acted upon in the manner that lead would be, only in a less degree. The shot or shell in such rifled guns requiring considerably more power to set it in motion as compared with the round ball from a smooth bore—the abrupt check of the wave of gas suddenly arrested in its progress—the amount of work to be done in whirling the projectile up to such a velocity in so short a space of time—the lengthened period during which the pressure exists in the rifled gun—as also the extremely violent action of the highly worked gunpowder which is used in England,—all these causes combine to render the effect of the powder upon the interior of large rifled guns very considerable, and involve a high standard of quality in the materials employed.

Before considering the fitness of any particular metal for the manufacture of rifled guns, let us enumerate some of the properties which are absolutely requisite to insure perfection.

The desideratum, then, for the interior and general structure of rifled guns is a material which should possess all the following characteristics:—

1st. That it shall be capable of withstanding the violent action of the most active gunpowder against rifled projectiles without producing the risk of fracture or even inordinate deterioration in the bore, and that it shall not be in danger of bursting at any future time by the effect of continual firing causing deterioration of the quality of the metal.

2nd. That the material to be employed shall have sufficiently high tenacity and general strength as will not render necessary the employment of a greater weight of gun than what is considered requisite by the artillerist to absorb the recoil.

3rd. That the material shall be sufficiently hard, so that the surface of the interior of the bore shall not in any way be indented or bruised, or otherwise acted upon, by the powder or projectile, or even by the premature fracture or explosion of a cast-iron shell within the bore.

4th. That the material shall be such, as that guns can be easily manufactured without much risk of radical defects, and that the guns, when properly made and proved, may with confidence be considered right in all respects, and without any doubt or uncertainty as to their positive soundness or future stability when in actual service.

5th. That the guns when made shall not be too costly.

Having already hinted that none of the existing metals, whether cast iron, wrought iron, steel, or even bronze, so far as I am aware, fulfil their function in all these conditions, still, having no other available source but

these, especially iron or steel, to fall back upon, let us consider some of their respective properties, and appreciate their fitness in proportion to their several merits; that being the best which promises these several conditions in the highest degree, and in the order of their greatest importance to the soldier in the hour of battle.

In order to be able to arrive at a correct comparison of the several metals, it is not only necessary to know definitely their respective resistance to compression and extension, but we also want to know with equal certainty their relative toughness, elasticity, and general behaviour, when exposed to strain combined with extreme vibration.

In regard to these two latter properties, little has yet been done to reduce them to the actual test of definite experiment, hence we can only infer from the general facts shown by the behaviour of the guns constructed of the several materials, and, as a rule, this is a very safe guide, providing there is sufficient experience on which to guide the judgment.

With regard to the strength of the several materials, especially their resistance to compression and extension, there are abundant data and full opportunity of obtaining positive knowledge so far; from which, however, if the other properties of toughness and elasticity are not considered, we are apt to draw a very unsafe conclusion.

With reference to the first of these properties, namely, compressibility, it is remarkable that the resistance to compression in each of the three materials referred to is more nearly equal than any of their other properties.

The pressure per square inch which is required in either metal to produce a permanent sensible indentation or shortening, about equal to three thousandths of an inch in measurement, ranges from 30,500 lbs. to 40,700 lbs.

This does not refer to the ultimate force which is required to crush the specimens into fragments, because for a gun that is of no consequence, as such an extreme test is not called into requisition. The proper material must be such that there is no sensible compression produced in the vicinity of the bullet-chamber by the force of the explosion or projectile. Hence the measure of strength or fitness is the point where the material begins to set permanently, and, so far, that is the best material which requires the greatest pressure.

Ten specimens of cast iron, parts of guns of the highest quality, but which have been severally burst, gave 35,000 lbs. per square inch; producing an average compression of three thousandths of an inch. The softest being 30,000 lbs., the hardest 40,300 lbs.

Ten specimens of rolled wrought-iron bar, made specially for guns, the specimens being selected at random and reduced from bars three inches square, all of the highest quality and suitable for guns, gave an average of 33,000 lbs. per square inch, with an average compression of three thousandths of an inch. The softest requiring 31,000 lbs., the hardest 35,000 lbs.

Ten specimens of wrought iron, cut from large gun-forgings of superior quality, gave an average of 26,900 lbs.; producing an average compression of three thousandths of an inch. The softest being 22,800 lbs., the hardest 31,000 lbs.

Ten specimens of soft cast steel of the finest quality, and that either withstood the proof-rounds, or which failed before the seven proof-rounds were completed, gave an average of 35,500 lbs. per square inch, with an average compression of three thousandths of an inch. The softest being 25,000 lbs., the hardest 46,000 lbs.

Ten specimens of cast steel, more highly converted than the former, and in quality almost fit for cutting instruments, but which broke first round at proof, gave an average of 76,000 lbs. per square inch, with an average compression of three thousandths of an inch. This kind of steel therefore need not be considered as of any value, however good in other respects, it being totally unfit for guns or armour-plates from its brittleness or want of the necessary toughness to withstand the vibration.

A specimen of cast steel, cut from a gun made by Mr. Krupp, of Essen, but from a gun which failed at proof, gave 25,300 lbs. per square inch, with a compression of three thousandths of an inch.

Four specimens of steel and iron, welded together like layers of sandwiches, gave in the direction of the fibre, that is, pressing the steel and iron upon the edge of the sandwich, an average of 26,000 lbs per square inch, with an average compression of three thousandths of an inch.

Four specimens upon the flat of the sandwich, thus pressing the two metals closer together, gave an average of 25,400 lbs. per square inch, with an average compression of three thousandths of an inch.

It will thus be seen, according to these experiments, which were all made on carefully prepared specimens, exactly one inch in length and half an inch in diameter, that the average resistance to three thousandths of an inch compression, or shortening, was as follows:—

	lbs.
1. Cast steel	35,500
2. Cast iron	35,000
3. Wrought-iron bar	33,000
4. Wrought-iron forgings	26,900
5. Sandwich steel and iron on edge	26,000
6. Sandwich steel and iron on flat	25,400
7. Krupp's cast steel	25,300

The chief point to be observed in regard to the compression of cast steel, which is the highest on the list, namely, 35,500 lbs., is the wide range from the softest to the hardest, from 25,000 lbs. to 46,000 lbs.; this characteristic of want of uniformity is found to be its prevailing feature and failing, and is the case with all the steels, even from the best houses which have come under my examination; and from the nature of its manufacture it is perhaps impossible to make steel positively uniform.

But if it could be made uniform, and if to the harder steels could be superadded the property of toughness so as to keep together, and if at the same time the brittleness could be withdrawn so as to give it the opportunity of recovering from vibration, it would then be invaluable both for guns and armour-plates; but so long as the cast-steel manufacture is uncertain in its produce, no matter how good it may be occasionally, the gunmaker will look upon it with suspicion, as a single failure produces so much mistrust.

The second on the list is cast iron, which is also very high, 35,000 lbs., and so far is good, but, like steel, it has also a wide range, from 30,000 lbs. to 40,300 lbs. If this metal had tenacity and toughness in proportion to its incompressibility it would, from its cheapness, have the decided preference; but so long as England is aiming at high results in her gunnery, the want of those properties will prove a strong objection to its adoption for rifled guns, unless cast iron can be much improved in tenacity and made more certain in its general character.

The third on the list is wrought-iron bar at 33,000 lbs., with the small range of from 31,000 lbs. to 35,000 lbs.; and this is the peculiar feature of wrought iron, it is never high nor never low; on the contrary, wrought iron from any particular maker, who is careful in the manufacture, is found to be nearly uniform, and, being possessed of great toughness and being without brittleness, it is exceedingly reliable so far as its strength will permit.

The fourth is that of wrought-iron forgings, which is considerably under bar iron, 26,900 lbs., also with a wider range than bar, and hence the less valuable so far—from 22,800 lbs. to 31,000 lbs.; the hardness and softness of large forgings being so much affected by the locality of the blows upon the mass.

The fifth and sixth upon the list are the Sandwich specimens, which are not of so much importance, except that as combinations they have been found to stand in some applications where steel failed from brittleness, and where soft iron was found to yield from lateral bulging; and no doubt the low position is partly due to the condition of the iron, and also to the soft quality of the steel which was necessarily used in order to get a good sound welding between the two classes of material, the iron and steel.

The softest material on the list is the famous cast steel made by Mr. Krupp of Essen. Only two specimens were operated upon, and gave 25,300 lbs. As will be seen, the hardness of this material is considerably under wrought iron, and, so far, is that much inferior in this respect. This material is so soft as to admit of being flattened down to any extent; indeed, the same remark applies to most of the good qualities of steel which are under 40,000 lbs.; they continually yield more and more by the increase of pressure, and the structure of the steel shows a wonderful adaptation for keeping together without cracking at the edges, unlike almost any of the other descriptions of material. This property is greatly in its favour, both for guns and armour-plates; and if it could be made to resist a sudden shock as well as it does the effect of mere pressure, it would be exceedingly valuable.

It will thus be seen that the several classes of material here referred to do not differ so much in the foregoing respect as might be expected, unless we are to include the extremely hard qualities of steel, which are from their hardness and brittleness obviously unfitted for guns; such qualities of steel rise up to 80,000 lbs., and can only be made available for the purposes in question by a long course of annealing, which is a process that may be continued until the metal is as soft as the lowest specimens which have been referred to; such softness, however, diminishes their value in proportion to its amount.

In regard to the other property, namely, that of tenacity, there is a

much greater difference existing between the cast iron, wrought iron, and steel, and it has also to be observed that they differ still more in their amount of elasticity and capability of stretching before fracture.

Cast iron and hard steel invariably break at the moment of perceptible elongation when the specimens operated upon are in short pieces, while wrought iron and soft steel have a considerable amount of elasticity, and only begin to permanently elongate after a certain load per square inch has been suspended, and they gradually continue to stretch with every increase of load until final rupture takes place.

As the measure of strength of any material wherewith to construct a gun, is the point at which permanent elongation commences, that point should have the chief attention; still it is requisite for comparison to specify the ultimate strength as well, in order to show the margin of strength which lies beyond this point; thus the several metals can be compared in regard to their relative fitness so far as the property of tenacity is concerned.

From several hundred experiments made with the higher qualities of cast iron which were collected with a view to obtain the strongest iron for cast-iron guns, the ultimate tenacity was found to range from 10,886 lbs. up to 31,480 lbs., or an average of 21,173 lbs. per square inch.

This is considerably above the strength of the greater proportion of the cast iron of commerce. The average of the Nova Scotia iron, specimens of which have recently been tested, gave only 15,821 lbs., and some of the Scotch pig-iron selected at random only gave 12,912 lbs.

It will be observed that the foregoing are the ultimate breaking points of cast iron, and gave no stretching or appreciable warning before fracture.

Of late years, and up to the present time, cast iron has generally been used for heavy guns, but its low tenacity and brittle, uncertain character renders it peculiarly unfitted for this purpose, and more especially is it unfit for rifled guns, as in them not only is the strain considerably increased, but the duration of the strain is prolonged in addition, thus producing a rupture before the particles have recovered from the vibration.

It is therefore inferred that, until an element of toughness can be given with certainty to that weak material, it can never be thoroughly depended upon in the construction of the armament of the future, notwithstanding its cheapness and facility of construction.

Although a small piece of cast iron under the testing process gives no warning, yet cast-iron guns which have stood the proof rounds, if closely watched, begin to show the lines of future failure long before the period of ultimate fracture, and the practised observer can generally indicate the probable number of rounds that will elapse before the gun gives way altogether.

At the same time there are several instances on record of cast-iron guns having exhibited an extraordinary amount of endurance, but the toughness is variable and uncertain, and nothing uncertain is to be commended.

From several hundred experiments that have been made with wrought iron cut from bars intended for the manufacture of Armstrong guns, the following result has been obtained.

The point of yielding permanently gives an average resistance of 28,000 lbs. per square inch, while the point of ultimate rupture gives an average of 57,120 lbs., or rather more than double that of the point where

permanent elongation commences; the margin that lies between these two amounts is of great importance as a condition of safety, but the chief point is that where the stretching begins.

After the first yielding by the addition of extra weight, the wrought iron specimen gradually stretches until it has been considerably reduced in diameter; and such parts as have been so reduced have a greater tenacity per square inch than when in the previous normal condition. The iron has to a small extent assumed the character of wire, which from the drawing process is always stronger than the iron out of which the wire is made.

This increase, however, if given to wire, is lost afterwards when the iron or wire is brought to a welding heat, and hence for gun purposes this property cannot readily be taken advantage of.

From ten specimens of wrought iron cut out of heavy forgings, a lower result has been obtained than from bar iron, such forgings being inferior in all respects.

In such masses, from their not having an equal amount of working in proportion to the extent of heating to which they are exposed, the tenacity is not so high as that of the more highly worked rolled iron when it comes direct from the rolls. In forgings, the average point of yielding permanently was 23,760 lbs.—average point of ultimate fracture being 48,160 lbs. The forgings from which the specimens were cut were all of high quality.

When rolled bars of the best quality are wound into coils, and then welded into cylinders for gun manufacture, the iron as a general rule is found to suffer to about 3,481 lbs. per square inch on the average.

The following shows the average results both in regard to yielding and breaking:—

Yielding point.	Iron in bar - - - -	31,100
	" cylinder - -	27,852
Rupture point.	Iron in bar - - - -	58,986
	" cylinder - -	55,500

The loss is due to the necessary heating being greater in proportion than the working.

From experiments that have been made to ascertain the tenacity of welds of iron of different qualities, and under different circumstances, it has been found that with iron of the finest quality, when brought to the proper heat in a fire free from impurities in the fuel, and with the joint scarfed so as to increase the area, the strength is equal to that of the solid iron, which is of course all that could be desired, and is in round numbers about 25 tons, or 56,000 lbs. per square inch.

With all other descriptions of weldings which I have yet tested, the result is lower than the above, down even to 12,000 lbs. per square inch, the same care having been observed in every instance.

Two pieces of the best quality of iron butted together, under the best conditions which I have been able to effect up to the present time, have only given an average ultimate tenacity of 32,140 lbs. per square inch, which is only a little over the half of the iron bar.

Iron butt welded to steel under the best conditions invariably breaks at the weld, and shows only an average tenacity of 26,800 lbs.

But even this depends entirely on the nature of the iron and the steel; any increase of hardness or of the steely property, either in the iron or in the steel, affects the strength of the weld in many cases down to 10,000 lbs. and even still lower.

In the construction of the Armstrong guns the bar iron is first wound into a spiral coil, and then a welding heat is taken through the entire mass, and by means of a steam hammer it is welded into a homogeneous cylinder.

With iron of the very best quality which we have as yet been able to obtain, the highest average tenacity of the welding of the coil has been 32,140 lbs. per square inch, the iron being 55,500 lbs.

With other iron also of high quality and of still greater tenacity, the welds have been lower down, even to 10,000 lbs. per inch; hence such iron, however strong, is, from the steely property, unsuitable for being made into coils; the defect being due to the reluctance shown by harder and stronger iron to unite when raised to a temperature that will not otherwise injure the quality of the material, and cause it to blister.

It will thus be seen that the ultimate strength of a coil in the circumferential direction is about 55,500 lbs. per inch, while in that of its length it is only 32,140 lbs. per inch, and when stronger and harder iron is employed it is even much less in the latter direction and the difference is proportionately greater; hence such steely iron must be avoided for purposes where much dependence has to be put on the welding.

In building up guns of cylinders, this high tenacity afforded by the coil system circumferentially, and the opportunity which it gives of knowing the soundness of the gun structure in every part, and from the fact that every part of the gun is put under the full exercise of its duty from the commencement,—this arrangement of building up guns will always have an immense advantage over guns made of a single solid forging in point of strength and security against bursting of the whole structure; and even when the coiled cylinder is considered as a means of obtaining the inner lining or bore of a rifled gun, a purpose for which it is by no means so perfect, yet even in that respect it is superior to the bore which is formed within the heart of an immense forging, of dimensions suitable for a large gun, such a mass of forging being always more or less defective even under the best and most careful workmanship.

This remark does not apply with the same force to the bores of guns when formed from a smaller forging in which the exterior only has been left as a shell or tube; the outside of such a forging, when properly treated, has a tenacity in all directions equal to that of the solid forging, consequently it is not so strong as the coil in the circumferential, at the same time it is considerably stronger in the longitudinal, direction, and is much more free from defects than the heart of a greater mass in larger forgings.

Turning to cast steel, we find that the range of tenacity is extremely wide—from 114,000 lbs. down to 67,000 lbs. per square inch—but it so happens that the higher qualities, judging from Woolwich experience, are altogether unsuited from their brittleness and great tendency to fracture, and, considering that no metal should be taken into account but that which can be depended upon, I shall only refer to qualities that have been successful in resisting the proof rounds. This quality averages about

80,000 lbs., and it is generally found that the weakest are really the strongest, and if the supply of suitable steel could be obtained with unvarying precision in regard to that degree of hardness, tenacity, and toughness, which is sometimes produced, it would be all that could be desired; but, unfortunately, it is fickle, treacherous, and uncertain, and hence for certain parts of the Armstrong gun that were formerly of steel, and for which some of the properties of steel are desirable, wrought iron of fine quality is now substituted, which, so far as not breaking is concerned, answers the purpose most satisfactorily, although not so good as steel in other respects.

The gun supplied by Mr. Krupp, which was formerly referred to, but which failed at proof, gave a tenacity of 72,000 lbs.; judging from the appearance of this metal beforehand, its softness and perfect soundness, I had great expectation of its being all that could be desired, but was disappointed.

Such a mass of homogeneous steel, after having been cast into an ingot, all its impurities floated to the surface, then well worked under the hammer, and afterwards properly annealed, has a degree of perfection in the bore in regard to entire freedom from specks, seams, or flaws, superior to any wrought-iron structure, coiled or forged, and some remarkably fine guns have been constructed with such steel linings, having the main structure of the gun built up with wrought-iron hoops to give the requisite strength to the steel lining. Such a combination gives the perfect bore and the strong gun, but there is not yet sufficient experience to enable me to assert positively, that the steel will not give way under long-continued firing; but the great difficulty lies in the inability of the steel-maker to insure uniformity, for an occasional gun bursting destroys all confidence.

Such are the several metals now used as materials for guns. Cast iron is the cheapest but the least trustworthy. Wrought iron, built of coiled cylinders, will afford the greatest strength, and is the least likely of all to burst by continued firing; and although in the first instance it will cost three times as much as a cast-iron gun, yet, as its endurance is more than ten times greater, judging from recent results, and as it is never likely to burst with any reasonable amount of firing, I consider it the safest investment, even in a money point of view.

The wrought-iron solid-forged gun, when moderately sound, is much superior to the cast-iron gun, but is inferior to the built-up wrought-iron gun; and, considering the chances of defective bores in the large masses of solid forgings, it will be found as expensive as the latter, and not nearly so reliable.

Cast steel is the most expensive of all, yet, from its soundness in the bore, if it could be made as trustworthy as wrought iron, and if at the same time it could be depended upon for the certain possession of toughness, it would be perfection, notwithstanding the cost; but the uncertainty of manufacture which now exists must first be completely removed before it can be compared with wrought iron as an instrument for men to fire and stand alongside with perfect assurance of safety; and, as wrought iron is so reliable and the cost moderate, there is no particular want felt for steel to constitute the entire body of the gun.

What the world requires is a quality of steel that will be perfectly reliable as an interior lining to a wrought-iron built gun; such a com-

bination will secure all the conditions that are wanted to meet the requirements of the artillerist at the present time.

Such steel should be considerably harder than wrought iron, at the least equal to 50,000 lbs. required to produce sensible shortening on a square inch, but at the same time it must be without brittleness and possessed of toughness at least equal to soft wrought iron, entirely free from honeycomb defects throughout, and which can be produced in a manner and by a process so definite, that there will be no change in the supply and no risk run of uncertainty in the quality of a crystalline structure that shall not be rendered brittle by continued firing, but which shall be as permanently safe and hold on, like good sound wrought iron.

These are high conditions not yet reached, so far as I am aware—not that it is not occasionally attained by some of the best steel makers, and hence there is hope to encourage perseverance; but at the present time, even with the greatest care, the precise quality is uncertain; still, by inferring from the progress recently made in the manufacture of iron and steel, and the great advantage which will accrue to those who are successful, we may reasonably expect that, by aiming high and with a well-directed effort, those conditions will ultimately be realized, and the gun-maker, by a judicious combination of a steel bore within a built-up wrought-iron structure, will be enabled to give the soldier a perfect instrument on which he can implicitly rely, and which will last for ages; meanwhile, considering the materials of iron and steel, as we now find them, and after balancing all the several advantages and disadvantages, wrought iron is the most reliable, even if not so perfect in other respects.

Friday, February 21st, 1862.

CAPTAIN E. G. FISHBOURNE, R.N., C.B., in the Chair.

REMARKS on the PROPOSED SPITHEAD FORTS in connection with the ADVANCED SEA-WORKS advocated by Mr. W. A. BROOKS, C.E. for the DEFENCE of PORTSMOUTH and the ADJACENT ANCHORAGE.

By W. A. BROOKS, Esq. Mem. Inst. of C.E.

THE title which I have given to the paper which I have been allowed the honour of bringing before your useful Institution may appear to place me in the position of being fairly charged with presumption, in thus intruding the opinions of a civil engineer on a subject which seems to be essentially one of a purely military character; but the sequel will, I trust, show that it comes within the range of my long experience in works in which the influence of the tidal currents constitutes an important element; and to this department of the question I shall first direct your attention.

In the observations which I shall also have to make when drawing a comparison between the relative powers of defence offered by the isolated circular forts proposed by the Royal Commission on the National Defences, as contrasted with those of the advanced sea-works projected by myself, I must at once admit that the usual duties of the civil engineer are so far foreign to those of the military engineer, that the necessary preliminary study of the subject is usually so entirely absent on the part of the civil engineer, that any interference on his part will rarely fail to cause the old caution of *ne sutor ultra crepidam* to be justly applied to him.

Acting under the guidance, however, of an experienced officer of the Royal Engineers, practical civil engineers and contractors would become most useful auxiliaries; but without that guidance, or without the preliminary study of the principles of fortification, both of field and permanent works, the intrusion of their services would be found to produce injurious results.

While yet a youth I became the possessor of Carnot's popular work, "An Account of the Defence of Fortified Places." Its glowing language warmed me to the subject; and for years I entered with enthusiasm into the studies of the military engineer, and in doing so became the possessor of a large collection of the best works written here, and on the continent, on the subject of fortification, both field and permanent; so that, although now inferior in information to probably the youngest officer of the corps of Royal Engineers, I nevertheless have that confidence in approaching the purely military part of this paper, which nothing but a previous professional study would give.

When, on the 21st of June last year, I had the honour of being allowed to submit to the Royal United Service Institution my plan of Langston Mole, and other sea-works for the improvement and defence of Portsmouth and Langston Harbour, as well as of the Roadstead of Spithead, I treated those works simply as addenda to the isolated forts recommended by the Royal Commission on the National Defences; and in that respect hardly did justice to my own projected works, in so far as the latter would virtually supersede the necessity for carrying into execution two, if not three, at least of the costly forts recommended by the Royal Commission, viz. those on the Horse and Spit Sands, and possibly even of that proposed to be erected on the useful position of the Sturbridge Shoal, in the event of a hostile squadron having been able to force a passage between the more advanced forts.

In the paper which I then read, * I confined my remarks to the effect which the works proposed by myself would have upon the tidal currents in their vicinity, and upon the Roadstead at Spithead and Portsmouth Harbour; but it does not appear that any public notice has hitherto been directed to the question as to the effects which will be produced by the influence of the isolated forts upon the local tidal currents; and to this subject I shall at once endeavour to direct your attention, the forts referred to being described on the chart as the centres of the red circles of radii of 1,000 yards, showing also their supposed effective fire at that distance of 1,000 yards by red radiated lines.

First. In respect to the alterations in the navigable channel into Portsmouth Harbour, which will result from the erection of the fort proposed by the Royal Commission on the Spit Sand, near the Spit Buoy.

This work would produce an injurious effect upon the sailing channel, because it would cause a considerable deposit of sand and shingle in a direction east-south-east of the fort, and would convert into a circuitous course the present straight channel abreast of the Spit Buoy. It would cause two deflections to be made by the current of the ebb out of Portsmouth Sea Reach, both of which would be attended with a diminution of available navigable depth in the channel.

I am fully borne out in this opinion by the records of the set of the current of flood-tide which appear in the "Sailing Instructions into Portsmouth Harbour," which are to the effect that "at the Spit Buoy the first four hours of the flood run east-south-east towards Langston Bar." During the above period the tide runs strongly, and therefore under the lee or east-south-east side of the fort there would be comparatively still water, and a deposit would assuredly take place in it of all sand previously held in suspension by the current of the flood-tide.

The Sailing Instructions proceed to state, that "on the fifth hour of the flood it turns and sets weakly towards Southsea Castle, and the remainder of the tide sets at the rate of about a knot towards the harbour."

From the above set of the governing current it is clear to me that the Spit Buoy Fort, if made even of the small external diameter of 200 feet, cannot have a safe foundation against the scour which will take place without the latter being of a diameter at its base of 637 feet, as per an-

* Vide Journal of the Royal United Service Institution, vol. v. p. 560.

nexed drawing; and as this mass of rubble will be directly opposed to the stream of flood, no question can in my mind, as a practical man, arise as to the great extent of deposit, or formation of a spit of sand, which will take place on the east-south-east side of the fort in question. The nature of the alteration or change in the contour of the sands has been drawn by me on the chart.

The Sturbridge Fort is proposed to be built on what is in reality the tail of the Mother Bank, although a flood-tide swatchway appears to separate it from the outer spit of the Mother Bank; and this fort will have to be built on a sand which has on it a depth of about 3 fathoms at low water of spring tides. This sand is of a most lively character, and has deep water close to it; the channel on the north side of the Sturbridge having 14 fathoms at low water, and that on its south side 10 fathoms.

The tides also run heavily over this shoal, so that it would not be safe to assume that a rubble foundation could be obtained, and maintained harmless from the scouring action of the tide, at a less depth than 6 fathoms at low water. This extra depth below the present surface of the shoal is however merely a question of cost, and it is only necessary to reason upon the effect of the presence of that portion of the work which will be above the level of the surface of the shoal.

If this fort be therefore made, like that on the Spit Sand, of a diameter of only 200 feet, its foundation will have a breadth of 637 feet opposed to the flood-tides which run strongly there for four hours from north-west to south-east. The result of the establishment of this obstruction to the tide in the shape of the Sturbridge Fort must therefore be that of a considerable extension of the shoal to the south-east of the fort, extending beyond the Sturbridge White Buoy, and filling up the useful 10-fathom anchorage ground.

The fort proposed at the Horse Buoy lies eastward of the sailing channel to Portsmouth, and therefore, although from the same causes it must have the effect of creating a deposit south-east of it, the latter will not produce any injurious effects upon the navigation, so far as regards the set of the first four hours of the strongest run of the flood-tide. During the last three hours of the tidal supply, or of that which comes into the harbour of Portsmouth and the roadstead of Spithead from the south-east, the obstruction will not be such as to produce any injurious effects.

The fort on No Man's Land Shoal will be certain to cause the formation of an extensive spit of sand in a south-easterly direction; but in this case I am of opinion that this new shoal will favour the defence of Spithead roadstead, as it will be the means of limiting the available sailing course for ships of large draught of water to the main channel between the Warner and the Horse Elbow Buoy of the Horse Sand; whereas at present they can pass, at or near high water, up the channel south of the Warner. The new spit of sand would in fact intercept their progress.

I may here observe, that a reference to the text of my Lecture "On the Advanced Seaworks for the Defence of Portsmouth," will show that I attributed to the erection of Langston Mole, and also to the fort proposed by me on the Warner, precisely similar effects to those which I have herein assigned to the forts proposed by the Royal Commission, viz. a deposit or accretion to the east and south-east of them; but that, so far as regards

defensive purposes, the result which would be produced would be useful, as I have just stated in respect to the shoal which would be formed to the south-east in consequence of the erection of the fort on No Man's Land Shoal.

No Man's Land Fort is the southernmost of the seaworks proposed by the Royal Commission for the defence of Portsmouth and Spithead, and does not diminish very materially in importance, even when taken in connection with the more advanced works in a seaward direction, proposed by Admiral Sir Thomas Maitland, on the Warner Shoal, and that of Langston Mole by myself; which latter I humbly conceive carries out in its integrity the view of the Royal Commission, and of many eminent naval and military men, that Portsmouth shall be made free from the danger of being shelled by the smaller hostile vessels which at present would find sufficient depth for them on the Horse Sand to approach near enough to throw their shells into Portsmouth Dockyard, and yet be out of the effective range of the fire from the five forts proposed by the Royal Commission.

The object of all who bear in mind the importance of preventing our principal naval station from being shelled, must doubtless be to keep the enemy's ships at such a distance from the arsenal that they shall not have the power, even while hotly engaged by our own ships, of taking the opportunity of at the same time throwing shells into Portsmouth.

However powerful might be the fire from the forts, if established on the Horse, No Man's Land, the Spit, and the Sturbridge Sands, it would not do to give an enemy the chance of fighting so close to our own arsenal. It will be too late to prevent the destruction of the arsenal if the fight occurred in Spithead Roads. The enemy's ships would be sunk or surrendered, but probably not before the firing of the arsenal had been effected.

It is this view which brings to Langston Mole and the Warner Breakwater the honour of support from the many highly distinguished naval and military men whose names I am allowed to mention as favourable to the construction of those advanced sea-works.

By the establishment of Langston Mole, and the breakwater on the Warner Shoal, it would become quite practicable to make use of floating booms or rafts to impede or foul the passage of a hostile squadron into Spithead Roads, a measure which would be extremely difficult and costly, and in fact almost impracticable, if the breadth of channel were only increased by the space across the Horse Sand of a full sea mile in breadth, over which, at tide time, ships of large draught would be able to pass.

By the construction of Langston Mole and the Warner Breakwater, aided by partially-placed obstructions in the shape of booms or rafts, an enemy's squadron, if not previously stopped seaward of the Warner, would certainly be arrested there, and brought to action out of shelling range of the dockyards, and would have to confine his attention to the then, to him, more engaging objects by which he would be surrounded.

Our plated defence blockships would run into and grapple with his ships, down anchor, and make them stand and fight it out, while their flanks would be exposed to an overwhelming fire from the ships lining

each side of the channel, or lying moored in the channel on the west side of Langston Mole and the Warner Breakwater.

In my previous Lecture I proposed to follow the recommendation of Admiral Sir Thomas Maitland to construct a fort on the Warner Shoal; but so exposed a situation during heavy weather from the south-east would be more fit for the site of a breakwater, behind which our ships could more effectually deliver their fire than could be done from the fort on which heavy seas would break. I also consider that any fort placed there or elsewhere, unless presenting a very large frontage, would be liable to sudden destruction by an active foe by the adoption of very simple means, and I therefore propose the substitution of a rubble breakwater of 400 yards in length, as per accompanying section, behind which, as in the case of ships moored in the channel at the back of Langston Mole, our ships would be able to pour over its crest a destructive fire with comparative impunity to themselves from the effects of a hostile return from ships steaming up the channel.*

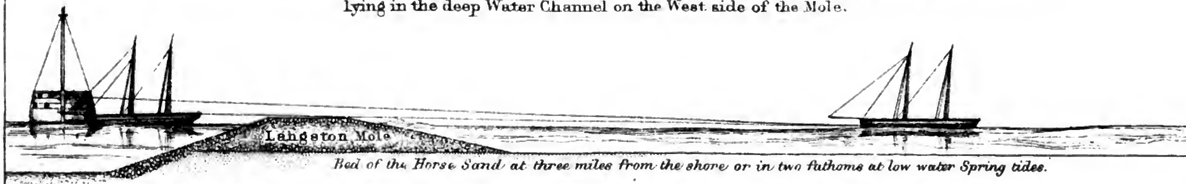
As regards the mode of attack upon the isolated forts of dimensions similar to those proposed to be erected on the edge of the Horse Sand in two and a half fathoms at low water, and on the Sturbridge in three fathoms, it is clear that, at tide time, there will at those places be ample depth for the passage of ships on both sides of those forts close to them; and we have now to consider some ready and simple means of blowing up or disabling those forts, even supposing they were plated with wrought-iron ten inches in thickness and backed with granite.

Imagine one of these circular forts of a diameter of 200 feet, but, for security against scour, provided with a rubble foreshore of 50 feet in breadth at the level of high water of spring tides, and further protected by long rubble slopes, forming a circle or mound of stone having a diameter of about 600 feet at the base, close to which latter there would be more than sufficient depth of water for a vessel of large draught to pass at or about high water,—if it be really necessary to interfere with the forts at all, considering the respectful distance at which ships will be able to steer clear of them, and that there will be no occasion to dance attendance upon them when the sole object of the attacking force would be the destruction of the naval arsenal, the ready means of levelling the walls of such a fort would be for two iron-plated ships to assail it, towing between them one or more coir warps, to the centres of which tow-ropes or warps there should be attached cylinders each containing about a quarter of a ton

* In the Report of the Royal Commission of Feb. 26, 1861, addressed to the late lamented Lord Herbert, there is a short description of the forts proposed to be constructed to defend Spithead and Portsmouth, as follows:—

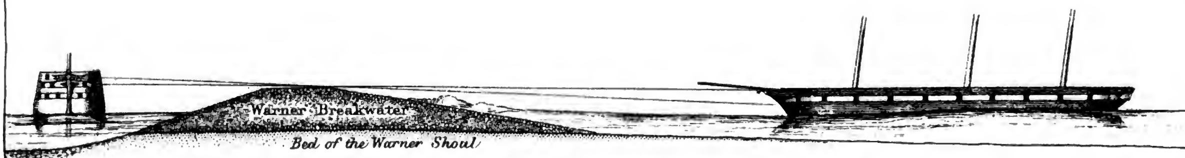
"Sec. 15.—The forts now designed for erection on the shoals at Spithead will be of a peculiarly formidable description, and essentially different from any works that have hitherto been built. They will be constructed for 120 guns, in four tiers, of iron 10 inches in thickness from low-water mark, unless it is found expedient to carry the foundations of solid granite up to high-water mark. They will thus be individually in every respect invulnerable to any species of projectile, and impregnable by any force of ships that can be brought against them, or by any conceivable mode of assault. Their vertical walls, 60 feet in height, will render them inaccessible by boarding, a mode of attack suggested by the writer of the pamphlet [referring to that by Captain Coles], and the foreshore of the foundations will effectually prevent the approach of explosive vessels sufficiently close to cause damage to the works."

Approach to Portsmouth barred by proposed Langston Mole, which can be defended by Ships and Gunboats lying in the deep Water Channel on the West side of the Mole.



High Water Transverse Section of Langston Mole where constructed on the outer division of the Horse Sand or in 12 feet depth at low water Spring tides.

Approach to Spithead defended by block ships moored under cover of the proposed Warner Breakwater and Langston Mole.



Section at low water of Spring tides of the Warner Breakwater where constructed in a depth of three fathoms.

Scale One Inch = 160 Feet.

W. A. Brooks, C. E.

J.R. Jobbins

of powder. On nearing the fort the ships would only have to separate, one steering past the north and the other the south side of the fort, and in doing so the case of powder would suddenly be lifted out of the water and lodged against the iron face of the fort, the contact with which would fire the percussion fuses attached to the former, and down would go the fort as the attacking ships slipped the ends of the cable and passed safely in its rear. In one of my own operations for the removal of wrecks, a simultaneous discharge of four canisters, containing together 940 lbs. of gunpowder, placed against the hull of the "Lady Feversham" (a coal-laden ship of 900 tons burthen, which sunk in Shields Harbour in five fathoms at low water), lifted into the air one-half of that ship and its cargo, together with a column of water of 45 feet in height, being the depth of the canisters below the surface of the river at high water, or at the time of the explosion; so that practically I have very great faith as to what would take place upon saluting one of the proposed isolated forts with a good charge of powder. To insure success it would only be necessary to give a good dose of powder.

It is clear, therefore, that it would be utterly unsafe, and a waste of money, to construct small isolated circular forts unless the same are effectually protected against such a means of attack as I have suggested; and therefore I consider, that, in assigning to the fort a foreshore of only 50 feet in advance of its walls, I have taken a minimum in every respect as regards the efficiency of the fort and its cost; for it appears to me that the foreshore should be very extensive, and raised at least 10 feet above high water of spring tides, and with slopes of 5 to 1.

One of these forts, if founded in 3 fathoms at low water, or without going to a greater depth than that for its foundation, would, in that item of foundation alone, if raised to only 6 feet above high water, cost not less than 200,000*l.*; and I may safely affirm that the foundations of the forts which it would be necessary to construct in the hope of their being able to keep ships, or gunboats, from getting within shelling range of Portsmouth Dockyard will entail an expenditure of not less than 800,000*l.* This amount does not include the cost of the foundations for the forts on the Sturbridge and No Man's Land Shoals; which forts in themselves offer no defence against Portsmouth being shelled.

A reference to the chart will make it clear that to keep ships and mortar vessels from getting within shelling range of Portsmouth Dockyard, in addition to the two forts proposed by the Royal Commission to be built on the Horse Sand, it will be necessary to construct two other forts more to the eastward, or in fact nearly on the very line proposed by me to be taken as the proper direction for Langston Mole; the northernmost fort being placed equidistant from Cumberland Fort and the Royal Commission Fort on the centre of the Horse Sand; and the southernmost fort equidistant from the latter and the fort proposed to be erected near the Horse Buoy; their exact positions being the centres of the red circles of 1,000 yards radii on my outer line of defence.

In the foregoing observations on the foundations of the forts proposed by the Royal Commission, in the absence of any published detail of the mode proposed to be adopted, beyond the mere fact that it is understood that the forts are to be of a circular form, of a diameter of 200 feet, and faced with

wrought-iron plates of a thickness of 10 inches, I believe that I have acted fairly in assigning to their foundations a mode of construction which will be safer and more economical than any other which can be carried out. It would be possible to carry the iron forts upon screw piles, or upon a series of cast-iron cylinders, as is, I believe, proposed by a member of the Institution of Civil Engineers, but either of those plans would entail a much greater cost, and would not be secure against the scouring effects which would be produced by the interposition of the work to the strong run of the tides of both ebb and flood. If the very useful invention of that experienced civil engineer Mr. Gibbs — who patented about 30 years ago the system of procuring foundations by cast-iron cylinders, such as we see now executing within a quarter of a mile of the walls of this Institution in the form of the piers of the new Hungerford Railway Bridge — were adopted, there would be not the less a necessity for protecting them with a rubble foreshore. In fact it would be a most dangerous mode of construction to found the forts upon any system which would leave them exposed to the scour of the tides, or would render them liable to be destroyed by the explosion of large masses of powder.

I have already shown how practicable it would be to lift the explosive charges of powder to the base of an iron-cased fort, although that base were raised several feet above the level of high water of spring tides, and therefore it will be at once apparent how much more easy it would be to blow up a fort whose walls are carried up vertically from deep water, or supported either upon cylinders of cast-iron, or by screw piles from the level of low water.

By the provision of an extensive rubble or rock foreshore in advance of the iron forts, or the most effective mode of resistance, I am relieved from the accusation in "Tom Thumb," that "He made his giants first and then he slew them," because it would be enough to augment the height and width of the foreshore to render the explosions of powder comparatively harmless. This increase of the foreshore would, however, vastly add to the cost of the rubble foundations, which will be onerous enough even with the limited dimensions which I have assigned in order to keep down the cost of the isolated forts, and which I purpose hereafter to detail when contrasting the same with the estimates for Langston Mole and the Warner Breakwater.

The 200,000*l.* must therefore be looked upon as the minimum expense which will be incurred in obtaining a proper foundation for each of the forts proposed by the Royal Commission, and will be far below what must be spent to obtain one for the fort on the Sturbridge Shoal.

I trust that in my comments on the proposed circular forts, which have, in all probability, been adopted by the Royal Commission simply on account of the greater cost of the superior system of defence which from the time of Vauban up to the present day has universally been admitted by all scientific men as the best, I shall not be considered presumptuous in thus making myself the humble means of expressing the opinions of all those who know the high value of forts when planned by military engineers unfettered by cost: in the words of Major M'Crea of the Royal Artillery, "The only way in which I can understand that forts can be dangerous is, when the ships passing them are exposed to their direct

cross fire;" and I will add, that that cross fire should be delivered from batteries whose faces should be of sufficient length, or the distance between the guns such as to give the artillerymen a chance of seeing the object they have to aim at.

The fire from the small isolated circular forts (for, after all, they are only martello towers upon a larger scale) will be completely obscured after the first discharge of their own guns; and, when the wind blows from any point between north-west and south-west, an enemy's flotilla advancing to the attack would be completely obscured. If, again, the wind blew from the opposite quarters, or between north-east and south-east, the small available number of ports of these circular forts would be equally obscured, and the object to be struck could only be guessed at by the flash from the guns; and thus the powerful artillery of the fort might be delivering its fire upon a small gunboat in lieu of a frigate, which was at the same time rapidly advancing under cover of the veil of smoke.

Captain Coles, of the Royal Navy, has in his pamphlet demonstrated that, by taking 1,000 yards as the limit of the effective range of even a 100-pounder Armstrong gun against a plated frigate, the forts recommended by the Royal Commission are too distant from each other to effectually command the sailing channel between them; as will be manifest by reference to the chart, where the strong red lines described by a radius of 1,000 yards from the Horse Shoal Fort and the fort proposed on No Man's Land Shoal leave a free channel of about 400 yards clear for the passage of an enemy's ships; which channel, however, rapidly expands into a wide and free channel, owing to the diverging nature of the fire from a circular fort. A ship would be through this narrow channel before a second shot could be fired at her from each of the guns of the forts.

Hence the advantage of batteries disposed so that a ship while approaching would be compelled to remain for a considerable time exposed to a direct fire. Steaming along at the rate of ten miles an hour, she would give no chance of the guns of the fort being re-laid at her after the first discharge.

This brings us back to the position, that the line of defence should be confined to the smallest possible limit of breadth of channel; and this, in the case before us of the defence of the approach to Spithead, can only be attained by the establishment of a permanent barrier across the Horse Sands and a breakwater on the Warner Shoal, which, limiting the available channel to a breadth of 5,500 feet, will enable it to be in time of war rendered difficult to pass by mooring rafts or booms in it, the exact position of which would be unknown to an enemy, inasmuch as they would be capable of being placed on either side of the channel, or in its centre, so as to compel those ships of an enemy which succeeded in passing them, at all events to previously undergo the ordeal of a close and concentrated fire from the ships moored in the channel at the back of the Mole and the Warner Breakwater.

During heavy weather from the south-east the moorings of the rafts and booms could be slacked away, so as to bring them under the shelter of the Mole and the Warner Breakwaters. In time of war, additional obstructions might be presented by mooring other rafts seaward of, or in advance of, the outer line of defence of the Mole and Warner, so as to

keep an enemy longer under their cross fire; and, in fact, the several rafts might be so arranged as to prevent a direct course being made by an enemy into the harbour. These could readily be slipped from their screw moorings during heavy weather from the south-east. By those advanced sea-works of Langston Mole and the Warner Breakwater, Spithead Roadstead would be converted into a perfect harbour; and its entrance would become as safely defended as the western channel of the Solent at Hurst Castle will be by the construction of the judiciously arranged works planned by the Royal Commission. It is well known that the area of deep water is exceedingly limited in Portsmouth Harbour, when regard is had to the vast increase of colossal ships of war which is being made, for which ships no station is so convenient as Spithead when the British Channel has to be defended.

Langston Mole and the Warner Breakwater would present as good a defence as could be made to the entrance of Southampton Water, of which Major M'Crea, in his able letter, says:—"If the passage across Southampton Water at Calshot Castle could be made impassable, so as to secure a dockyard eight miles up at Southampton, where our future iron navy could securely retreat and repair, then the value of such an outlay, however vast, might be well appreciated by the nation."

Just so, I submit, would be the expenditure upon Langston Mole and the Warner, which, at the cost of less than a million of money, or, in fact, at less than what must be disbursed upon the foundations of the isolated forts proposed by the Royal Commission for the defence of Portsmouth, would provide the desideratum of Major M'Crea, but without entailing one-tenth of the cost of erecting new establishments at Southampton, to supply the place of those now existing at Portsmouth.

From observations on the set of the streams of flood and ebb recorded on the Admiralty Chart, the following deductions may be made:

1st. That the main, or strongest, current of the flood-tide comes through the northern channel, or by the Solent Sea, for the first five hours of the tide, and that that stream receives an augmentation of its volume during the remainder of the natural duration of its flow of 6 hours and 12 minutes from the tidal wave which comes round the back of the Isle of Wight and enters Spithead from the south-east.

2nd. That the directions of the flood currents of both the northern and the southern channels are not such as would be intercepted by any work like the mole proposed east of the entrance into Langston Harbour, so as to impede the flow into Portsmouth or Langston Harbours.

3rd. That the effect upon the northern flood current by the interposition of Langston Mole upon its progress, after passing the mouths of Portsmouth and Langston Harbours, must be that of accumulating the water against the concave face of the mole and forcing it up to a higher level in those harbours.

4th. That the effect of the presence of the mole upon the tidal stream which enters Spithead from the south-east must at least be innocuous, as the supply will pass easily up the spacious channel which will be left between the mole-head and the north shore of the Isle of Wight, the same being 14,000 feet in breadth, or ample for the full volume which is required to fill the Solent and its tributaries; and because the mole itself lies

eastward of the course which the tidal wave takes, which now affords the supply on the latter part of the flood-tide.

The tidal stream in Langston Harbour, where confined in its course, has in its natural state a depth of from 5 to 7 fathoms at low water of spring tides, and on the ebb the water rushes out during the third, fourth, and fifth hours with a velocity of 3¼ knots per hour, its course being towards the southern channel, or eastward of the Isle of Wight, and its velocity such as will ensure a deep channel alongside of the concave face of Langston Mole, sufficient for our largest line-of-battle ships to lie afloat there at the lowest ebbs. In this capacious channel, ships moored in it would be covered by the rubble masonry of the mole, the seaward face of which would form a glacis, over the crest of which their artillery would be able to deliver their fire in any direction, either to prevent the approach of gunboats to it, or the shore of Hayling Island to the eastward.

In this channel our old line-of-battle ships would, in fact, as aforesaid, become moveable batteries, and as formidable as if plated with iron, so effectually would their hulls be masked by the mole.

The almost immediate effect of the erection of the mole would be to considerably shoal the water eastward of it, so that it would be impracticable for even a gunboat to get at high water within shelling range of Portsmouth Dockyard.

The mole would thus effectually protect the shore from any attempt at a landing on it anywhere within the range of the ships' batteries; which useful range against gunboats we will assume to be one nautical mile, or abreast of the village of Hayling; and, as the deep-water channel of the eastern stream in Langston Harbour is sufficient for our block-ships, it would be impossible for an enemy to establish any batteries on Hayling Island near enough to shell the naval arsenal of Portsmouth without being within point-blank range of the guns from our ships, as the latter would be moored in a channel at a distance of from four and a half to five miles eastward of the dockyards. This will be fully acknowledged when it is remembered that the eastern shore of Langston Harbour is above five miles distant from the eastern side of the dockyards, and the latter will be, therefore, unassailable on the landward side nearer than Portsdown Hill.

Batteries would doubtless be established at other places on the coast, so as, in like manner, to render the establishment of a landing difficult westward of Selsea Bill, and thus place a long day's forced march between Portsdown Hill and the shore eastward of Selsea Bill, and give sufficient time for us to be enabled to concentrate our forces, to intercept, and save the enemy the trouble of breaking ground on Portsdown Hill.

To complete the seaward defence of Portsmouth it will, however, be still necessary to guard the channel of 14,000 feet in breadth, which will remain between the end of Langston Mole and the northern shore of the Isle of Wight, near Nettlestone Point. This object will be effectually carried out by a portion of the works recommended by the Royal Commission on the National Defences, combined with another on the Warner Shoal, a most advantageous position, as lying immediately between the south end of Langston Mole and the Isle of Wight, the northern edge of the Warner being only nine cables' length, or little more than a statute

mile, distant from the mole-head. The site of this shoal was proposed by the gallant Admiral Sir Thomas Maitland as a fit place for the erection thereon of a fort seaward of those recommended by the Royal Commission. Its value, however, is immensely enhanced when combined with a work like Langston Mole, which will have the effect of compelling an advancing foe to pass under its fire.

The depth of water on the Warner Shoal is from two and a half to three fathoms at low water of spring tides; this shoal I am of opinion will however be rendered more useful by being raised up to the level of a few feet above high water of spring tides, so as to form a breakwater, under the shelter of which our wooden walls would be as effective as those proposed by me to defend the approach to Langston Mole.

The length of this mole on the Warner may be at first made of four hundred yards, and its effect will be, as aforesaid, to form a shoal lying in front of it, and bearing north-west and south-east; such, in fact, as will ensue by the erections proposed by the Royal Commission on the Sturbridge, Horse, and No Man's Land Shoals.

These eastward extensions of No Man's Land and the Warner Shoals will add materially to the defence of the approach to Spithead, as they will, even at high water of spring tides, render it impracticable for steam frigates to approach by any other channel than that between Langston Mole and the Warner, and the second line of permanent defence, consisting of the forts on No Man's Land and the Horse Sands ; the whole defence consisting of a very formidable quadrilateral.

Another advantage in this defence is, that, if an attack be made on it during the flood tide, the latter runs here so slowly as to be of little service in accelerating the passage of ships, the greatest velocity of the current from the south-east being only one knot per hour.

The cost of Langston Mole necessarily depends upon the nature of the work: thus, a chalk and rubble reef (as per sections) run up to the level of 6 feet above high water of spring tides, with sufficient seaward slopes to enable it to remain permanent until it became drifted up with sand and shingle, would not cost more than 500,000*l.*; and it may be certainly taken as a matter of reliance that this result would rapidly follow the protrusion of the Mole over the shoal ground of its site. Witness the immense annual accretions on the shore of Hayling Island of both shingle and sand. In fact, so great is the effect of gales from the south-east in driving up shingle, that it would be only necessary to erect a jetty of iron piles and sheet-piling over the line of the intended mole to insure its being rapidly buried up on its seaward side in a mass of shingle and sand. If this construction were necessary on account of despatch, one-half of the length of the mole might be raised to the level of high water of spring tides by a single length of iron piling, and the southern division completed by two sorts of piles, the first brought up to the level of half tide, and subsequently raised on the accumulation of shingle which would be produced by driving the lower range of piles. The facility with which Langston Mole would be completed, owing to the shoal nature of its site, is such, that it may be safely stated that it could be run out to its full length over the East Winner and Horse Sands, before either of the piers at Dover or Alderney could be extended 600 feet further seaward.

I shall confine myself in my estimate to the good old-fashioned system of construction of breakwaters by rubble and chalk, with long seaward slopes, and assume that it would be necessary to provide the latter of as permanent a character as if really exposed to seas such as the Plymouth and Cherbourg breakwaters have to withstand. In this case Langston Mole is proposed by me to be raised to the level of six feet above high water of spring tides, with seaward slopes of 6 to 1, and on the harbour side with slopes of 3 to 1; precaution being also taken to provide rubble for forming the concave face of the six-fathom channel, which will be scoured out by the discharge from Langston Harbour on the creation of the mole. The mole to have also a top breadth of 70 feet, to give room for portions of it being capable of being raised to a greater height in order to more effectually mask the hulls of our line-of-battle ships moored in the channel along. As a simple breakwater or mole, a top breadth of 22 feet would be sufficient.

The total cost of such a mole will not exceed 727,827*l.* if made of a top breadth of seventy feet and of a length of 6,200 yards; and of 491,699*l.* if of a length of 5,000 yards; which latter, if approved of, would probably be the length at first ordered to be constructed and contracted for. In both of the above estimates the large amount of 20 per cent. has been added for contingencies.

To complete the outer line, or advanced sea-works, the cost of the breakwater of 400 yards in length on the Warner must be added; this length will mask four old line-of-battle ships. In this case, if partly made of chalk blocks transferred from the end of Langston Mole, covered with a mass of Portland or Swanage stone, or in fact strongly cased with rubble as per annexed drawing, the estimate would be:—

	£
For chalk for the core, 221,200 cubic yards, at 5*s*. . .	55,300
For stone for facing the same, 163,600 cubic yards, at 12*s*. 6*d*.	102,250
	157,550
Add 20 per cent. contingencies . .	31,510
	£ 189,060

Cost of Langston Mole, 6,200 yards on the Horse Shoal .	727,827
Breakwater on the Warner	189,060
Making the total cost of the outer line of defence . .	£ 916,887

If however it be considered advisable to form the Warner Breakwater altogether of rock or rubble work, this, with 20 per cent. for contingencies, would amount to . .	288,600
Add Langston Mole, for its full length	727,827
Total cost of the outer line of defence	£1,016,427

So large an amount having been provided for contingencies, both in the price of the work and the bulk of material, it may be relied on that one million sterling will form both Langston Mole and the Warner Breakwater; which, if defended by our wooden walls alone, and the channel between guarded by iron-plated ships, will afford a much more effective defence than if the whole of the five forts proposed by the Royal Commission were constructed. It has been proved, however, that if the whole five of the forts were constructed as recommended by the Royal Commission, viz.: two forts on the Horse Sand, one on No Man's Land Shoal, one on the Spit Sand, and one on the Sturbridge, they would not be sufficient to prevent a squadron of iron-plated ships from running between them and taking up positions from which they could shell Portsmouth Dockyard and burn both Portsmouth and Portsea, without being within a mile and a half of the guns of the proposed forts.

It has also been proved that those forts would not prevent gunboats, or other vessels of light draught of water, approaching from the eastward over the shoal ground of the Horse, and also getting within easy shelling range of the dockyard and Portsmouth; while at the same time they would be out of effective range of the fire from the five forts proposed by the Royal Commission, and also of the shore forts. To prevent an attack by gunboats, at least the two additional forts in the line of Langston Mole before noticed must be constructed on the eastern verge of the Horse Sand, and those works alone, viz. the two additional forts, would cost more than Langston Mole.

The question of the cost of the forts proposed by the Royal Commission should be carefully considered, as well as the effective defence which they would procure, or rather the amount of it. Both would be very easy to estimate closely, provided the plans or mode of construction were made public; it is however enough that we know that they are to be of a circular form, with a diameter of 200 feet at the level of high water, to be enabled to readily ascertain, at all events, what their foundations alone would cost. These forts, if they are not to be exposed to be blown to pieces by the explosion of large cases of powder towed to their bases by vessels steaming on each side of them, as before mentioned, must be provided with a broad and rugged foreshore of rubble, carried up to the level of at least six feet above high water of spring tides, and with slopes so much inclined as to prevent vessels of fifteen feet draught of water getting within a less range than 150 feet of their bases at high water of spring tides. This will be effected by a foreshore of fifty feet in breadth, and with slopes of five to one from the level of six feet above high water to low water of spring tides, and below that level with slopes of three to one. If this rock or rubble-work base for the fort be founded in only eighteen feet depth at low water, the cubical yards of stone required will be 276,230, which, at 15*s.* per yard, including contingencies, will amount to 207,172*l.* It will be here remembered that I have estimated the rock-work on the Warner at 288,000*l.* if raised to the same level of six feet above high water of spring tides.

In round numbers, the bases of the forts recommended by the Royal Commission will each cost not less than 200,000*l.*, and if they are to be surmounted by iron forts, provided with ten-inch plates or walls, and carried up as proposed to the level of sixty feet in height above low water,

the superstructure of each fort will not cost less than 200,000*l.*, and therefore each fort not less than 400,000*l.*; and, after all, what will be the amount of the effective fire of each fort? The circular form which has been adopted is the weakest as regards the number of guns which they will be able to bring to bear against a hostile force advancing against them. If the forts consist of three tiers of batteries, not more than four guns in each tier will be effective against an approaching ship, or not more than would be better delivered from a single corvette's broadside.

The corvette's battery of twelve or fourteen guns would have the advantage of being comparatively clear of smoke, but who will pretend that any precision of fire can be expected or sustained for any length of time where three or four tiers of guns are simultaneously discharged? Surely the effect must be the same as in a three-decked ship, where the order is so frequently given to cease firing, in order to allow the smoke to clear away.

The exceedingly limited face which the effective fire from a circular fort gives will allow it to be easily masked by the fire of two or three gunboats, the smoke from which would be such as to shroud the advance of the more formidable frigates, which would form a portion of the attacking squadron.

If Sebastopol or Cronstadt forts had been merely circular, instead of presenting long lines of formidable batteries, nothing from them would have prevented the approach of our wooden walls.

Notwithstanding the great weight of the opinion of the Royal Commission on the question of circular forts against the usual long batteries which for several centuries have entirely superseded circular forts (except in the cases of martello towers, where a long line of coast has had to be defended at a small comparative cost), I do not hesitate to declare my humble opinion as opposed to the construction of the isolated forts proposed by the Royal Commission for the Defence of Portsmouth and Spithead, while I subscribe willingly to the propriety of their advice in recommending the construction of certain permanent works or forts, in aid of the defence by floating batteries. If forts are to be built, the best positions will be those selected by the Royal Commission at the Warner, No Man's Land Shoals, and at the Sturbridge; but the latter would have the injurious effect of causing the formation of a long spit of sand tailing down from it in a south-east direction, and shoaling up some of the best anchorage ground of Spithead Roadstead.

In lieu of the circular fort proposed to be constructed on No Man's Land Shoal, which would not give so good a fire as from a single iron-plated corvette, I believe that it would be more advantageous to construct upon it a fort of much larger dimensions, with two lines of batteries to defend the approach to Spithead Roads from the south-east, whose junction would form a re-entering angle of 135°, or thereabouts, the northern face or battery bearing north-north-east and south-south-west, and the southern one from north-north-west to south-south-east; the northernmost battery having a length of 600 feet, and the southernmost also 600 feet of effective length for the position of guns, thus affording ample space for working 55 heavy guns on the lower or casemated tier, and as many mounted *en barbette.* The fort should present to an approach from south, by compass, two similar faces of 400 feet each, and similar

faces also on the opposite or north side, which latter would completely command the roadstead of Spithead.

It has been, I believe, determined that only three of the forts proposed by the Royal Commission shall be constructed, viz. one on the southern verge of the Horse Sand near the Horse Buoy, one on No Man's Land Shoal, and another on the Sturbridge Shoal. But, inasmuch as at high water of spring tides there is a depth of 22 feet 6 inches over the Horse Sand at a nautic mile north of the proposed fort at the Horse Buoy, there will be no obstruction presented to the approach of the larger class of despatch gunboats, or even of the smaller corvettes. Aware of this fact, the Royal Commission evidently entertained a strong desire (as appears in the evidence) to establish a barrier of stone between the fort at the Horse Buoy, proposed by them, and Cumberland Fort.

I have shown that the five forts proposed by the Royal Commission will cost not less than 400,000*l.* each, and that, on account of their circular form, they will not be so effective as five corvettes moored near the same positions. Their aggregate cost will therefore be two millions, and for that sum I submit the effective defence will not be at all equal to the outer line of defence proposed by me at a cost of one million, viz. by the formation of Langston Mole and the Warner Breakwater.

In conclusion, I think that, now that the strength of England has been partly put forth, and that in a few months we shall be in possession of a commanding force of iron-plated ships of war, economy may be very fairly tried in reference to the outlay upon the projected iron forts, inasmuch as, by the establishment alone of the outer line of sea defence proposed by me, viz. Langston Mole and the Warner Breakwater, assisted by floating booms or rafts to render the channel more intricate, the wooden walls of Old England may be safely entrusted with the defence of Spithead and Portsmouth, while our ironsides may keep the Channel, or, when occasion arises, blockade those ports which require their especial attention.

Lastly. I have but a short time to notice the mode of construction now going on at some of our refuge harbours, as they are called. Alderney is being formed with lofty vertical walls, or nearly so, from the level of 12 feet below low water of spring tides, and from low water upwards is completely exposed to the fire of artillery. At a long range a few gunboats would undercut and topple down by a day's fire more of the masonry than has been built in a year. The works at Alderney are now being constructed in above 12 fathoms at low water. Dover Pier is now also being built with vertical walls, from the level of above 7 fathoms in depth at low water of spring tides, and presents a capital target for a gunboat to practise at. That pier is now costing about 1,200*l.* for each yard in length; and three or four well-directed shots from one of Armstrong's 100-pounders at a range of a mile and a half would bring down each yard in length of the granite facing, leaving it a ruin; and its destruction would be completed by a few shells delivered into its concrete core. Cherbourg Breakwater would be a still easier work to destroy, as its construction has not been of the massive character of the piers at Alderney and Dover; and therefore Cherbourg is not a standing menace, for its face wall seaward, where defended by batteries, would be a ruin after a day's practice at it with

shot and shell from our gunboats. It will be seen, from the above remarks on the circular forts, that I do not concur in the views of those gentlemen who consider that it is only necessary to make a work invulnerable in itself, in order to provide the best means of defence. This system carries us back to about the conclusion of the middle age, when defensive armour became so perfect that the wearers of it became incapable of hurting each other; and great battles, as they were called, took place with very little bloodshed on either side. Just so will probably be the effect of the heavy plating of our ships of war, which, in their present mode of construction, weakens instead of adding to the strength of their frames when opposed to the most formidable foe they will ever have to contend against—a tempestuous sea lasting for forty-eight hours together. In my humble opinion it will be better to remain satisfied with making our plated ships proof against shell alone, which 3-inch plates will effect, rather than encounter the enormous cost of iron plating, which, to resist the bolts of the improved artillery of the present day, had need exceed even 6 inches in thickness. Probably, in the long run, there will be greater loss of life by over-plating, over-weighting our ships of war, than in allowing shots of one or two hundredweight to pass clean through them, as did the 32-pounders in former fights. Recent experiments have shown, that, to effectually resist the bolt from a 100-pounder Armstrong gun, or, at closer quarters, the shot from an old 68-pounder gun, the plates with which forts or ships must be covered, must be of the very best iron, and have a thickness of five inches; but the experiment has not yet been carried out to the extent of ascertaining how far such plates would be able to withstand a broadside from a ship like the "Warrior," which could deliver a concentrated fire of twenty-four 100-pounders.

Bearing also in mind that 300-pounder Armstrong guns are now about to be tried—and few can doubt their eventual perfection, credit must be given to the naval and military advisers of our Government for the suspension of their decision as to the erection of forts, which, if even plated with 10-inch iron, at an enormous cost per ton, would probably be found to fail under the concentrated fire of such formidable artillery. Such artillery may, perhaps, also be considered of too valuable a nature to be allowed to be cased up in forts whose fire it may not be necessary to approach in order to effect a proposed object of destruction.

On the whole I must confess that, looking at the enormous strides which are being daily made in the improvement of artillery, the Government must also be allowed credit for judgment in giving a prior consideration to the construction of floating means of defence, and that, in the words of Major M'Crea, of the Royal Artillery, "the question between forts and ships cannot be considered abstractedly as a question of expense. If it were positively ascertained that the former were far better than the latter, or that they really could do their work, and prevent the entrance of an enemy to Spithead, I do not believe the country would cavil at any estimate, however enormous; nor is a high value to be placed on the fact that these forts can be themselves made invulnerable. It is not the amount of safety to the gunners within their *enceinte*, but the damage they can cause in so many minutes to an enemy, under circumstances of especial difficulty, which alone must be considered. Their merits in this balance are wanting. Iron-cased

ships, or forts in motion, can alone contend, with a reasonable chance of success, against similar forts in motion."

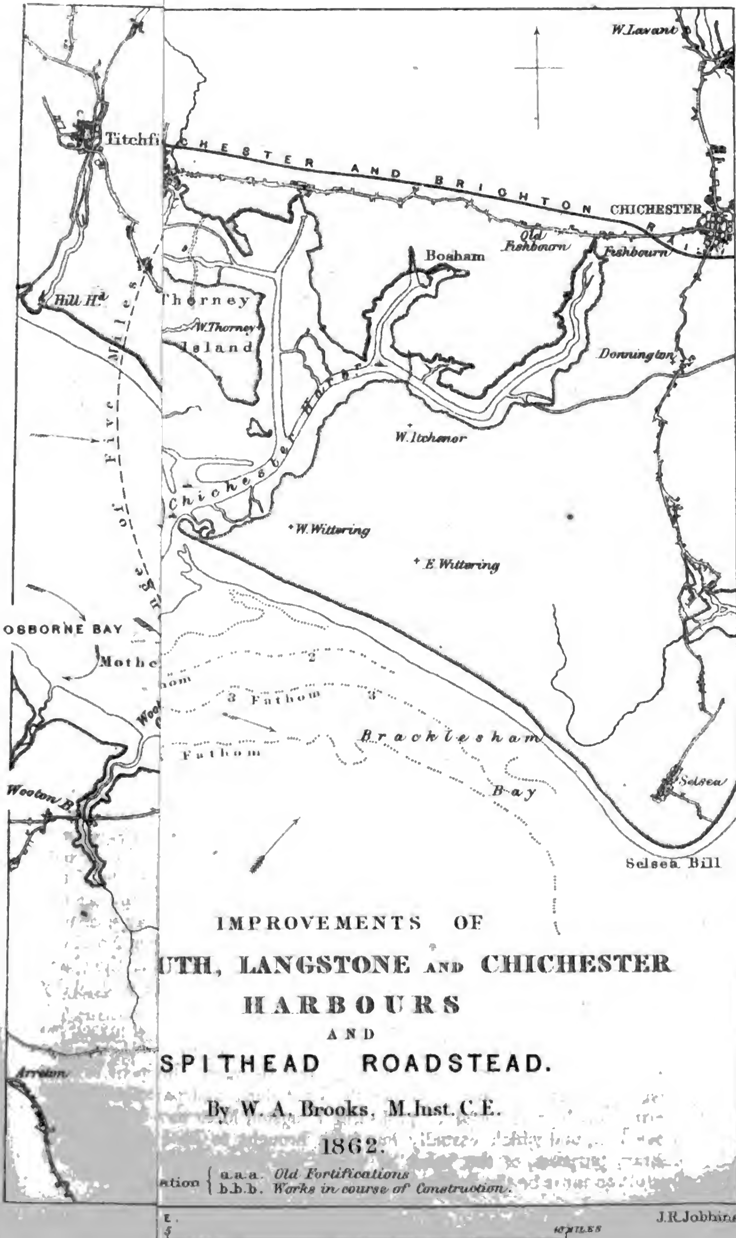
Coinciding with Major M'Crea in the above, I have carried his argument further, and applied it to the floating forts or ships, which in my opinion it is not advisable to attempt to make invulnerable, except as against shells, the effects of which they alone have to dread.

If, as I believe, guns will be constructed to throw bolts of three hundredweight, it will be only necessary to establish them upon floating batteries protected by the glacis of Langston Mole and that of the Warner Breakwater, to give the most effective and economical means of defence to the roadstead of Spithead. To the fire of such powerful artillery it will be nearly useless to oppose framework of any description in small masses, which will be exposed to a concentrated fire; and, in fact, in the present day, the defence afforded by the glacis of a fort becomes of infinitely greater importance than when the attack was limited to the fire from 18-pounder guns. Hence arises, in my humble opinion, the great value, in the shape of efficient protection, of the Warner Breakwater and Langston Mole; and hence also a doubt on my mind whether it would not be advisable to construct a breakwater also in advance of the fort proposed to be built on No Man's Land Shoal, leaving however a 5-fathom channel between it and No Man's Land Fort, in which channel gunboats or ships could lie, and in fact possibly supply the place of the proposed fort.

If this breakwater were made to run, as per plan, in a line bearing south by compass from the white buoy of No Man's Land, it would pass over 5-fathom water, and would keep clear of any deposit in the channel behind it, as it would be in the true run of the tide there. This advanced work would remedy the only existing defect of the position of No Man's Land Fort, viz. by enabling a fire to be brought to bear 400 yards nearer to the channel which has to be defended, than by the site selected by the Royal Commission, and make the main channel in fact of about the same breadth as between the Warner and Langston Mole.

I have elsewhere shown that the whole of the site of the Horse Shoal between Southsea Castle, the buoy of the Horse Shoal, and the western side of the channel leading to Langston Harbour, will rise considerably in height after the erection of Langston Mole, so that this very effect will supersede to a great extent the necessity of any fort on the Horse Sand, particularly if, as I have suggested, the defence on the south side of the channel be brought 400 yards nearer; and thus, in addition to the defence of the line of advanced sea-works proposed by me, it will only probably be thought necessary to have a powerful range of batteries at No Man's Land Shoal, as a reserve or second line of defence, inasmuch as the channel abreast of it will be capable of being also additionally secured by booms or rafts, as suggested for the advanced line of works.

Finally, after all that has been endeavoured to be said by myself so much in favour of my own project, it is in itself nothing more than might naturally be expected to emanate from one whose practice happens to have been for above thirty-five years especially devoted to that department of engineering which would lead to projecting Langston Mole as a harbour improvement, and which casually has been brought to be subservient to military purposes, of the value of which the Members of your useful Institution must be the best judges.



W. Lavant
Titchfi
CHESTER AND BRIGHTON RAIL
CHICHESTER
Old Fishbourn
Fishbourn
Bosham
Bill Hd
Thorney
W. Thorney
Island
Donnington
W. Itchenor
Chichester Harbour
Five Miles
W. Wittering
E. Wittering
OSBORNE BAY
Mothe
2
3 Fathom
3
Brackleshamam
Fathom
Bay
Wooton B.
Selsea
Selsea Bill
Arreton
IMPROVEMENTS OF
UTH, LANGSTONE AND CHICHESTER
HARBOURS
AND
SPITHEAD ROADSTEAD.
By W. A. Brooks, M. Inst. C. E.
1862.
ation
a.a.a. Old Fortifications
b.b.b. Works in course of Construction.
5
MILES
J. R. Jobbins

TABLE No. 1. (From the Admiralty Chart).

Of the times of low and high water at full and change days of the coast tidal wave which travels from the west side of the Isle of Wight through the strait between the Isle of Wight and Hurst Castle, and thence up the Solent.

	Time of Low Water. h. m.	Time of High Water. h. m.
In the North Channel west of the Isle of Wight	3·30	9.40
Yarmouth (Isle of Wight)	3·30	10·00
Lymington	4·00	10·25
Cowes	4·10	10·45
Southampton	4·00	10·30
Ryde	4·15	as below in Table No. 2.

TABLE No 2. (From the Admiralty Chart).

Of the times of the low and high water at full and change days of the coast tidal wave, which, on being split at the Needles, travels round the south coast of the Isle of Wight, and enters Spithead from the south-east.

	Time of Low Water. h. m.	Time of High Water. h. m.
At the Needles	3·40	9·46
Atherfield Point	3·40	10·20
Bembridge Point	4·00	11·00
Ryde	4·15	11·20
Cowes	as in Table No. 1.	11·45
Yarmouth	Ditto	12·00
Hurst Castle	Ditto	12·00
Lymington	Ditto	12·15
Southampton	Ditto	12·45
Abreast of the Warner	4·30	11·20
Portsmouth	4·30	11·40
Langston Harbour	4·40	11·40
Selsea Bill	—	11·45

Friday, March 7th, 1862.

Major-General the Hon. J. LINDSAY, M.P. in the Chair.

THE MOTION OF PROJECTILES FIRED FROM RIFLED ORDNANCE, AND THE ADVANTAGES OBTAINED BY THE EMPLOYMENT OF SUCH PIECES.

By Major C. H. Owen, R.A. Professor of Artillery, Royal Military Academy, Woolwich.

The subject that I have to bring before you to-day is so extensive that I can only be expected to give a very slight sketch of it in the short time allowed for a single lecture. I must, therefore, ask you to excuse any omissions that I may be compelled to make, as I should wish to dwell more particularly on those points which are of the greatest practical importance.

The art of gunnery appeared a few years ago to excite but little attention in this country; while many simple people not only hoped, but believed, when they witnessed the success of our first Great Exhibition in 1851, that gunpowder could scarcely again be required for warlike purposes—at least in Europe. However, the constant revolutions and wars that have occurred during the last few years have no doubt induced all but the "Peace-at-any-price party" to take some interest in an art the cultivation of which is so manifestly essential to the safety of a state.

In fact, shooting has now become a national amusement, and a vast amount of mechanical skill has lately been displayed in the invention and manufacture of improved firearms and projectiles of all kinds. Notwithstanding, however, the great interest taken in all questions concerning the relative merits of different firearms, we are as a people very ignorant of the science of gunnery. Yet, without some knowledge of its elementary principles, no opinion of any value can be formed, even from the results of the most careful experiments. Accounts of trials between different firearms are constantly inserted in the papers, and very rash conclusions often drawn by the public, every one thinking himself competent to give an opinion upon such apparently simple questions. One gun is said to shoot rather farther than another, and therefore it is the best; another gives more penetration, or has some other alleged advantage; or, to take a recent case—that of firing from smooth-bored and rifled guns at wrought-iron plates—in one of the trials the fire of the former produced more effect than that of the latter, and, therefore, it was immediately concluded that we had gained nothing by the introduction of rifled ordnance, and that, after all, smooth-bored guns are the best—a most absurd conclusion!

Projectiles are governed in their flight by certain mechanical laws, and hence the necessity of endeavouring to ascertain what these laws are; for, if absolute truth cannot be arrived at, a near approximation to it is obviously of very great practical utility. There is at the present time a complete surfeit of newly-invented firearms. Some of these are very valuable, and others practically useless, or very inferior to those that have been long in use; but the greater number are made quite independently of the actual requirements of the service for which they are intended—in fact, every inventor follows his own opinion as to the proper form of projectile, the velocity, the twist of the grooves, &c. Now, it is precisely these conditions of form, velocity, &c., which determine the accuracy of fire, the range, and penetration of a projectile, no matter what kind of gun is employed; and, therefore, it is highly desirable to ascertain, by direct experiment, the requisite conditions for particular purposes.

It should be clearly understood that there are two distinct questions, each of great practical importance, which now excite much attention. One relates to the projectile, and is more especially an artillery question; the other, relating to the gun, is a mechanical problem. It is necessary, first, to determine the conditions of velocity, form of shot, &c., requisite to obtain accuracy, range, and penetration—also the shape of projectile adapted to the destructive purpose for which it is intended; secondly, to contrive a gun which shall give a certain projectile the necessary initial velocity and velocity of rotation, and which shall combine excellence and simplicity of construction with the requisite strength, weight, and durability. In every case, when practicable, the gun must be made for the projectile, and not the projectile for the gun; and both, as well as all warlike *matériel*, should be of as simple construction as possible, for otherwise they will be liable to become unserviceable from derangement of parts, and the large bodies of men for whom they are provided will not understand or appreciate the various mechanical arrangements, and will, therefore, commit blunders in using them.

In my remarks to-day I shall not enter at all into the relative merits of different systems of firearms. In the first place, I shall consider the laws which govern the motion of an elongated projectile. I shall then endeavour to point out a few general principles derived from these laws. My concluding remarks will refer to the advantages obtained by the employment of elongated projectiles, instead of the spherical shot and shell previously used with smooth-bored guns, and the influence which the fire of rifled ordnance may be expected to exercise upon the operations of future wars.

Elementary Laws which govern the Motion of an Elongated Projectile.

It will be unnecessary to explain the nature of the motion communicated to a projectile when fired from a gun by the explosive force of the powder, or how that the shot is gradually brought to the ground by the action of gravity. It will be sufficient to remind you that the two forces of projection and gravity would together cause the centre of gravity of a shot to describe *in vacuo* a parabolic curve.

That the trajectory of a shot fired with a high velocity in the atmosphere

differs very considerably from a parabolic curve, in consequence of the resistance of the air, is a well-known fact; but I shall make a few observations on the circumstances upon which this resistance depends, for a consideration of these will enable us to understand why the ranges of projectiles fired from rifled ordnance are so much longer than those of shot from smooth-bored pieces.

Circumstances upon which the Resistance of the Air depends.—The resistance which a projectile meets with in moving through the atmosphere depends chiefly upon its velocity, and upon the magnitude of the surface it presents to the resistance.

Dr. Hutton found by experiment that the resistance of the air increases gradually up to a velocity of about 1,500 feet per second, when it varies as the 2·153 power of the velocity. The reasons assigned by Hutton for this gradual increase are as follows.—"The circumstance of the variable and increasing exponent in the ratio of the resistance is owing chiefly to the increasing degree of vacuity left behind the ball in its flight through the air, and to the condensation of the air before it. It is well known that air can only rush into a vacuum with a certain degree of velocity, viz., about 1,200 or 1,400 feet in a second of time; therefore, as the velocity is greater, the degree of vacuity behind goes on increasing, till at length, when the ball moves as rapidly as the air can rush in and follow it, the vacuum behind the ball is complete, and so continues complete ever after, as the ball continues to move with all greater degrees of velocity."*

In certain cases for the sake of simplicity, as in comparing the respective resistances to projectiles moving at different velocities, we may assume with sufficient accuracy for all practical purposes, that the resistance of the air varies as the velocity squared.

Retardation.—The velocity a projectile loses in consequence of the resistance of the air, or its "retardation," will, however, depend also upon its weight—being, in fact, inversely as the weight.

Elongated Projectiles less retarded than Balls.—Now, if two projectiles of similar weight but of different forms could be fired in vacuo with the same velocity, one would range as far as the other. In the air, however, any change in the form of a projectile not only affects the range but also the accuracy of fire. It will be sufficient here to notice the effect of form upon range.

If an elongated shot and a ball of equal weight be fired with the same initial velocity and angle of elevation, the former will be less retarded, and will consequently range farther than the ball, for the diameter of the elongated projectile being smaller than that of the ball, the elongated shot will not oppose so great a surface to the resistance of the air as the ball. For instance, if a 12lb. Armstrong projectile and a 12lb. ball be moving with the same velocity, the resistance of the air being assumed to vary as the squares of their diameters,

The diameter of the 12lb. Armstrong shot = 3 inches,
" " ball = 4·5 inches,
Therefore the resistances will be as 9 : 20·25, or 1 : 2·25.

* Hutton's 37th Tract.

From which it appears that the resistance opposed to the ball is more than twice that which acts against the Armstrong projectile; and this comparison, though rough (for the obliquity of the axis and the form of the point of the elongated shot are not considered), is sufficiently accurate to account for the results obtained in practice.

Range increases with the length of shot.—It will hence be obvious that as an elongated projectile is lengthened (its weight remaining the same), so the diameter being necessarily decreased, a longer range will be obtained.

Long ranges due to the introduction of elongated projectiles.—The long ranges of projectiles fired from rifled arms now in use are due to the substitution of elongated for spherical projectiles. The initial velocities of the former are usually much lower than those of balls fired from smooth-bored arms; but as, in consequence of their peculiar form, elongated projectiles offer so much less surface to the resistance of the air, their velocities are maintained for a longer time than those of balls. That this is practically the case, may be seen by an inspection of the following range table:

TABLE 1.

Gun.	Projectile.	Initial Velocity	Elevation.					
			1°	2°	3°	4°	5°	6°
		Feet.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.
12-Pr. Smooth-bore .	Ball	1,769	700	1,000	1,200	1,400	1,600	1,800
„ Rifled . . .	Elongated	1,184	680	1,015	1,335	1,655	1,956	2,218
32-Pr. Smooth-bore .	Ball	1,690	790	1,160	1,460	1,690	1,910	2,110
40-Pr. Rifled . . .	Elongated	1,164	720	1,100	1,455	1,810	2,160	2,505

That an elongated projectile maintains, up to a long range, a much higher velocity than a ball fired with even a higher initial velocity, will perhaps be made more apparent by the following comparison of the respective "initial" and "final" velocities of a ball and an elongated shell:—

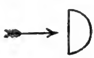
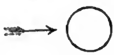
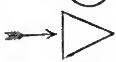
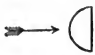
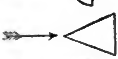
TABLE 2.

Projectile.	Range.	Time of Flight.	Initial Velocity.	Mean Velocity.	Final Velocity.
	Yards.	Seconds.	Feet.	Feet.	Feet.
40lb. Segment Shell (Elongated)	2,000	6·25	1,164	960	756
68lb Solid Shot (Ball) . . .	2,000	6·25	1,579	960	341

Now this case is favourable to the ball, the total weight and specific gravity of which are both greater than those of the shell, but it is nevertheless evident that the velocity of the ball has rapidly decreased in comparison to that of the elongated shell.*

Effect of Form upon Range.—The retardation of a projectile is influenced by the form of both its fore and hind part, but especially by the shape of the former. The following table† of resistances to bodies of different forms, moving with low velocities of 10 feet per second, is constructed from the results of Dr. Hutton's experiments with the "whirling machine" invented by Robins.

TABLE 3.

	Form of the Bodies.	Experimental Resistance.	Theoretical Resistance.
	1. Hemisphere, convex side foremost .	119	144
	2. Sphere	124	144
	3. Cone, angle with the axis 25° 42′ .	126	53
	4. Disc	285	288
	5. Hemisphere, flat side foremost . .	288	288
	6. Cone, base foremost	291	288

The experimental resistances to 2 and 3 are about the same, notwithstanding the sharp point of the latter. The resistances to the three last, which theoretically ought to be double of the two first resistances, are experimentally much more, in fact 2½ times as much.‡

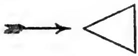
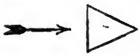
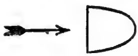
The next table is taken from Piobert's "Cours d'Artillerie," and contains the results of experiments made by Borda in the last century, with velocities of 3 to 25 feet a second.

* A long range is taken so that an error in time of flight may be small.

† Extracted from Capt. (now Lieut.-Col.) Boxer's Treatise on Artillery, page 152, art. 299.

‡ Dr. Hutton's remarks on these experiments will be found in his 36th Tract, page 190, vol. iii.

TABLE 4.

FORM OF THE BASE OF PRISMS.	Experimental Resistance.	Theoretical Resistance.
 1. Triangle, base foremost . . .	100	100
 2. Triangle, apex foremost . . .	52	25
 3. Demi-ellipse	43	50
 4. Ogival	39	41

From this table it appears that the ogival form experienced the least resistance.

Forms of Elongated Projectiles used.—With high velocities the results might perhaps differ considerably from the above, and experiments carefully executed can alone enable us to determine the form of projectile which will attain the greatest range with a given initial velocity. One of three different forms is generally employed for the head of an elongated projectile. The figures below represent sections of these three forms.

Fig. 1.

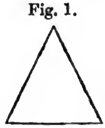


Fig. 2.

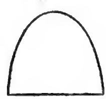


Fig. 3.

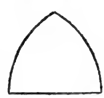
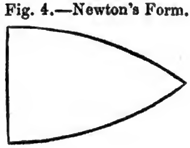


Fig. 1 is the section of a "cone." Fig. 2 is the section of a "conoid," or a figure generated by the revolution of a conic section about its axis. Fig. 3 is the section of a pointed arch, which is termed by the French "ogival." The last is most probably the best form, as the one which experiences the least resistance from the air.

Sir Isaac Newton in his Principia gives a form of body which would, in passing through a fluid, experience less resistance than a body of any other shape.

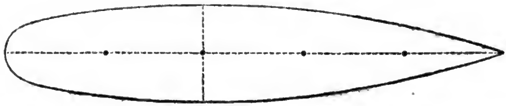
Fig. 4.—Newton's Form.



This form, it will be seen, is very similar to the ogival.

Piobert says that the form fig. 5 will experience the least resistance from the air. Its length is five times its greatest diameter, and its largest section is placed at $\frac{2}{5}$ of the length from the hind part.

Fig. 5.—Piobert's Form.



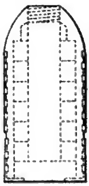
The shape of some of Mr. Whitworth's projectiles approach more nearly to this form than those of any elongated projectiles hitherto used.

Circumstances affecting the Accuracy of Fire of Elongated Projectiles.—The circumstances which affect the accuracy of fire with elongated projectiles must now be considered. Elongated projectiles cannot be used with advantage if fired from smooth-bored guns, for it is found in practice that at a short distance they turn over in their flight, and are therefore useless. This arises from the tendency of such bodies to rotate round their shortest axis, if a force be impressed upon them which does not pass through their centres of gravity. The force which turns them over is the resultant of the air's resistance, which acts below the point of the shot at all angles of elevation given in practice. In vacuo an elongated shot would require no rotation.

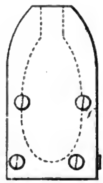
Influence of the Position of the Centre of Gravity upon the Motion of a Shot.—The position of the centre of gravity of an elongated shot influences the motion of the projectile. If it be placed very far forward, the shot, unless it have a very high velocity of rotation, will proceed with its longer axis coinciding very nearly with the tangent to the trajectory; but this position is unfavourable as regards accuracy, for the wind has great disturbing effect and causes uncertain deviations. If the centre of gravity be placed far back, then a very high velocity of rotation is indispensable to prevent the shot from turning over; and this high velocity of rotation is objectionable, for the following reasons:—The strain upon the metal of the gun will be very great, for the charge must be large, and the grooves will require a sharp turn, much resistance being thereby caused to the motion of the projectile; the shot, after grazing, will deflect considerably; and, should the projectile be a sharpened or segment shell, the pieces would spread laterally to too great a distance to be effective. However, the rapid rotatory motion of the projectile is favourable to penetration, and, perhaps, to range.

Effect of the Resistance of the Air upon a rotating elongated Shot moving with a high Velocity.—In almost all elongated projectiles in use the centre of gravity is situated in or very near the centre of the figure, and I shall therefore, in the following explanation of the effect produced by the resistance of the air upon the motion of an elongated projectile rotating rapidly, assume that the centre of gravity is in the centre of the figure; and also, that the shot has a "right-handed" rotation, *i.e.*, that the upper part turns from left to right with reference to an observer behind the gun, this being the rotation generally given.

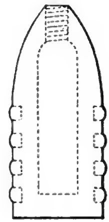
PROJECTILES FOR RIFLED ORDNANCE.



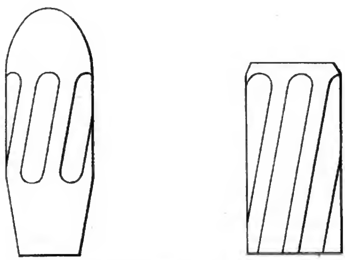
Armstrong.



French.

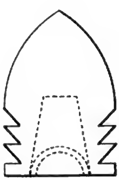


Prussian.

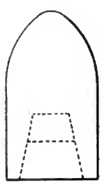


Whitworth.

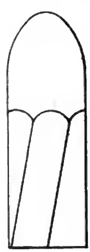
BULLETS FOR SMALL ARMS.



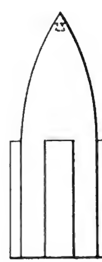
Minié.



Enfield.



Whitworth.



Jacob.

J.R Jobbins

When an elongated shot is fired from a rifled gun, it leaves the bore rotating rapidly round its longer axis; and if the initial velocity were very low, the projectile experiencing but slight resistance from the air, the longer axis would remain (as in vacuo) during flight parallel, or nearly so, to its primary direction. This I will show by experiment.

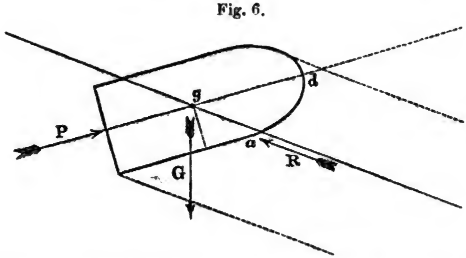
Before proceeding, it will be as well as well to remind you of the enormous force exerted by the resistance of the air upon a projectile moving with a high velocity. At a velocity of 1200 feet a second, which is about the initial velocity of the Armstrong projectiles,

A 100 lb. shot will be resisted by a force of			432 lbs.
40 lb.	,,	,,	203 lbs.
20 lb.	,,	,,	127 lbs.
12 lb.	,,	,,	79 lbs.

The effect of the pressure of the air upon an elongated projectile fired from a rifled gun may be observed by means of a gyroscope provided with a small elongated shot, and for this purpose, the shot having no motion of translation, a strong blast of air must be directed upon it, so as to cause similar effects to those which would be produced, if the projectile were passing with a high velocity through the atmosphere. It will be found that the effects produced will vary with the form of the point of the shot; therefore, in the first place, the effect upon a conoidal head will be considered, and secondly that upon a flat head.

Cylindro-conoidal Projectiles.—As before explained, the resultant of the resistance of the air will act upon a point in front of the centre of gravity and below the longer axis, at all angles of elevation given in practical gunnery. This may be at once perceived by referring to fig. 6.

Fig. 6.



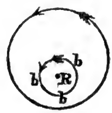
P represents the direction of the force of projection, *G* that of gravity, while it is obvious that *R*, the resultant of the resistance of the air, must be parallel to the trajectory described by *g*, the centre of gravity of the shot. The pressure *R* must always act in front of *g*, unless the centre of gravity is very far forward.

Experiment with Pressure.—If fig. 6 represent the elongated projectile of the gyroscope, it will be found that a pressure, *R*, exerted anywhere between *a* and *d*, will raise, unless the force acts perpendicular to the surface and through the centre of gravity, the point *d* when the projectile

is not rotating. Should, however, a rapid rotatory motion be given to the shot, the effect will be very different; for the point D will move round in a circle, the centre of gravity of the shot remaining at rest, so that a conical motion will be produced. Now, if the rotation is right-handed, the circle will be described from right to left, the line of pressure, R, passing through the centre of the circle. This movement of the point in a circle b, b, b, is shown in fig. 7.

Fig. 7.

Right



Left

The spectator, in this figure, is supposed to be in front of the shot looking at the point, and therefore his left will be the shot's right.

Experiment with the Blast of Air.—If I now direct the blast of air upon the projectile of the gyroscope first at rest, and then when rotating, similar effects will be produced. Should the rotation be left-handed, the circle will be described in the opposite direction, or from left to right.

Application of the Principle to the Case of an Elongated Shot fired from a Gun.—Now if this principle be applied to the case of an elongated shot fired from a gun, it must be evident that the longer axis will not remain during flight parallel to its primary direction, when the velocity is high enough to create considerable resistance; but the point of the shot will first move to the right, then downwards, and so on, describing a portion of the circle, the continuance of the motion depending upon the time of flight and the velocity maintained. As the velocity becomes low the circular motion of the point will become very slight and then cease; but in practice during the few seconds of flight which generally elapse, as the velocity is pretty high throughout, there is probably sufficient time and pressure, not only to turn the point to the right, but to bring it down on to the trajectory, or even below it.* With an artificial blast a very slight pressure is obtained compared to that exerted by the air upon a shot moving with a high velocity.

Long Axis not a Tangent to Trajectory with ordinary Elongated Shot.—It is very difficult to ascertain by experiment the actual position of the longer axis of a projectile at any part of the trajectory, but there is no doubt that the axis cannot, as it has sometimes been erroneously supposed, remain a tangent to the trajectory, unless the centre of gravity be very far forwards, and the velocity of rotation be low.

That the axis of an elongated shot inclines during the flight to the right may be frequently seen from the direction of the grazes; and it is almost invariably found in practice, up to 8° or 10° of elevation, that the effect produced upon an object is similar to what would occur, if the shot struck point first, which can only be accounted for by the drooping of the point. This drooping is of importance, for, did the axis remain

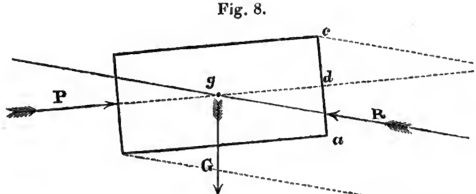
* Pointed out by Professor Magnus, in his paper on the "Deviation of Projectiles."

parallel during flight to its primary direction, the projectile would most probably, when fired at a high angle, on striking the object turn up against it lengthways, and therefore produce but little effect. This has not, however, been found to take place at the experiments hitherto made, but on the contrary, the penetrations of elongated shot are always remarkably great; and there is little fear of the shot turning up against an object unless the velocity both of translation and rotation be very low, and the angle of fire very high.

Deviation of Elongated Projectiles.—It is found in practice that elongated projectiles, fired from rifled ordnance giving a right-handed rotation invariably deviate to the right; and in the few cases tried with guns giving a left-handed rotation to the left. This peculiar deviation of projectiles fired from rifled pieces is termed by the French "derivation," and can only be accounted for by the turning of the point during flight, as already explained, to the right, the air acting therefore more on one side than on the other.* It has been supposed that the pressure of the air underneath the shot causes this deviation, the shot rolling to the right, in consequence of the great pressure below, compared to that above; but it must be remembered, that with shot fired at low angles, and with high velocities, the pressures above and below will not differ very much. There will, of course, be a more or less complete vacuum behind the shot. The "rolling" effect adds doubtless to the deflection of a conoidal pointed shot.

Effect upon a Flat Head.—The effect produced on a cylindrical or flat-headed projectile will now be noticed. A pressure exerted upon the head and below the longer axis, as R in fig. 8, will when the projectile is not

Fig. 8.



rotating cause the head to droop, or will produce an effect similar to a downward pressure acting at c; just the opposite to what was before observed with a conoidal-pointed projectile. It would therefore appear, that the fore-part of a flat-headed projectile fired with a right-handed rotation, would, in consequence of the resistance of the air, not turn to the right but to the left, and this is found to be the case if a blast of air is directed upon a projectile of this form in a gyroscope, the axis of the centre of the current of air being directed upon a point a little below *d* fig. 8. It has been asserted that flat-headed projectiles fired with a

* See Magnus' paper on the "Deviation of Projectiles."

right-handed rotation deflect to the left, which may be expected, from the turning of the front of the shot towards the left during flight.*

Circumstances upon which Penetration depends.—The penetration of a projectile depends upon a variety of circumstances, such as its velocity at the moment of impact, its density, diameter, nature of the object struck, and the relative position of this latter with regard to the trajectory.

The "work done" upon the material into which projectiles of similar form are fired may be considered proportional to $w v^2$, where $w =$ weight of projectile $v =$ velocity at the moment of impact.

Penetration of Elongated Projectiles.

The penetration of an elongated projectile is greater than that of a spherical shot of equal diameter and of similar density if they are both fired with equal initial velocities and at the same angle of elevation; for, the weight of the former being so much greater than that of the spherical shot, its penetration will be greater, and also it will be less retarded and have a greater final velocity, the penetrations being as the squares of their respective velocities at the moment of striking. In general, however, an elongated projectile is fired with a lower initial velocity than a ball of equal weight from a smooth-bored gun, and, therefore, at a short distance the latter will most probably produce more effect as regards penetration than the former; but as the range is increased so will the penetrating power of the elongated projectile be greater compared with that of the ball, for the former will maintain a high velocity much longer than the ball. It is only at very short ranges—such as 500 or 600 yards—that the fire of a smooth-bored gun is sufficiently accurate to allow of a comparison of its results with those obtained from practice with a rifled gun; beyond such ranges the accuracy of a smooth-bored gun cannot be depended upon, and the total effect produced by a number of balls upon an object would most likely be inconsiderable. But with a rifled gun the blows of its elongated projectiles can be repeated on the same part of the object at much longer ranges, and a wall or side of a ship could, therefore, be battered with effect at ranges where balls would be practically useless. The pointed form of the fore-part of the elongated projectile assists no doubt in increasing its penetration into substances such as earth or sand. But it is found that for penetrating very hard substances of comparatively small thickness—such as wrought-iron plates—a flat-headed projectile gives the best results, punching a hole completely through a plate which would defy the more pointed projectile. Some small projectiles of cylindrical form lately tried against iron plates gave very excellent results, punching clean holes of the same diameter as the projectile. Flat-headed projectiles have no advantage if fired against slabs of iron; but it has been found that the fore-part of a projectile of such form spreads out after making only a slight indentation. In order to obtain penetration into an iron slab or plate, the thickness of the metal must bear a certain

* Experiment has proved that flat-head shot having a right-handed rotation deflect to the left. See Appendix B. in an "Essay on the Motion of Projectiles fired from Rifled Arms," by Major Owen, R.A.

proportion to the momentum of the projectile, and, as the velocity of the latter is higher, its diameter and weight remaining the same, so will its penetrating power be greatly increased; in fact, increase of velocity will be of more advantage than greater weight as regards mere penetration. There is no doubt but that the rotatory motion of a projectile fired from a rifled gun greatly increases the penetration.

Principles derived from the preceding Remarks.

It will now be desirable to state a few general principles derived from the preceding remarks, and which may be capable of practical application.

1. *Accuracy of Fire dependent upon Velocity of Rotation.*—The "accuracy of fire" depends upon the velocity of rotation imparted to the projectile; the more rapid this velocity the more accurate will be the practice. As, however, a high velocity of rotation is objectionable for several practical reasons, it will generally be sufficient to give such velocity of rotation as shall be maintained throughout the flight of the projectile up to the longest range required.

It may be observed here that the velocity of rotation depends upon the turn of the grooves and the initial velocity of the shot.

Initial velocity in feet divided by number of feet in which one turn is made equals number of revolutions made by the shot in a second.

The charge must not be substituted, as is often done, for the initial velocity; for projectiles of similar form and equal weight, if fired with equal charges from guns rifled on different systems, will most probably have very different initial velocities. The electro-ballistic apparatus must in future be used in all cases when it shall be requisite to compare accurately the respective powers of different guns.

Heavy projectiles require less velocity of rotation.—The greater the specific gravity of a shot the less velocity of rotation will it require, for this velocity will be less diminished during flight by the resistance of the air.

Long projectiles require a high velocity of rotation.—The longer the projectile (the weight remaining constant) the greater must be the velocity of rotation given to it, in consequence of its greater tendency to turn over in flight.

2. *Accuracy of fire dependent upon stability of axis of rotation.*—In order to secure accuracy of fire it is essential that the axis of the projectile should correspond with that of the bore of the piece, for otherwise the axis of rotation will be variable, and the deflection of the projectile uncertain. Should the axis of the shot on leaving the bore be unsteady, the projectile will have the "wabbling" motion so frequently observed in experimental practice. It is therefore indispensable that the "bearings" of the projectile should extend along the cylindrical part, or should be very near the centre of the shot, for if they be either too far forward or behind, unsteady motion must result from the axis of the projectile being inclined to that of the bore.

When the whole length of the cylindrical part of the shot bears against the grooves, the projectile fitting the bore tightly, as is the case with almost all rifled small arms having leaden bullets, with breech-loading

ordnance, like the Armstrong or Prussian guns, or with the Armstrong "shunt" gun, L. Thomas's rifled gun, &c., the axis of the bore and shot must coincide.

When there is any windage, as in the case of all muzzle-loading rifled pieces with hard projectiles having projections or buttons, there must be a slightly oblique movement of the axis of the projectile; but still, if the bearings are over the centre of the shot, or there are two sets, one round the fore part, and the other round the hind part, as in the French elongated shot, the axis of the projectile will no doubt on leaving the bore be tolerably steady. With the Whitworth rifled cannon, the projectile being made to fit the bore so accurately, and there being such a very trifling amount of windage, the axis of the shot is practically stable on leaving the bore.

Other cases might be stated, and the results of practice shown to prove that the above principle is correct, and that a violation of it, by placing the bearings at random and in the wrong position, only results in giving an unsteady motion to the shot, thereby causing inaccurate shooting.

3. *Influence of Initial Velocity and Form of Shot upon Range.*—The range of a projectile fired from a gun depends chiefly, where the ground is level, upon the initial velocity, the form of the shot, the angle of elevation of the piece, and the height of the latter above the plane. It will be unnecessary to make any remarks here on the two last circumstances. The range of a shot increases in a much lower ratio than the initial velocity, and velocities of over 1,344 feet per second (or the velocity with which air can rush into a vacuum) are quickly reduced. When only moderately long ranges are required from ordnance—up to 2,000 or even 3,000 yards—it is found that with elongated projectiles an initial velocity of about 1,200 feet a second gives very satisfactory results. This being the case, it would not appear desirable to require a higher initial velocity, except for particular purposes, as for penetrating metal plates or slabs. With small arms long ranges are of little practical utility; still, as it is desirable to have as flat a trajectory as possible at all ranges, a higher velocity than 1,200 feet can be given with advantage, especially as there is no difficulty in giving the barrel of a small arm the requisite strength for a large charge. The ogival form of head most probably experiences less resistance from the air than either the conical or conoidal, and therefore it is the best of the three as regards range; it is also probable that tapering off a projectile behind increases its range.

It has been shown that the range increases with the length of a projectile. But too great length must not be given to a shot, for it is found that the wind exercises a considerable disturbing effect on very long projectiles, causing the practice to be uncertain both in range and deflection, according to the direction in which the wind is blowing. Another objection is that very long projectiles require, as before explained, a very rapid rotatory motion.

The length of projectiles for rifled ordnance is generally from 2 to $2\frac{1}{2}$ calibres, but bullets for small arms are sometimes 3 calibres long.

4. *Penetration chiefly Dependant upon a High Final Velocity, and upon the Form of the Shot.*—In order to obtain great penetration, a high final velocity is far more advantageous than great weight; and the form

of a shot must be adapted to the nature of the material fired at: if the latter be soft, it is better to have a pointed head; if hard, a rounded point; but when hard metal plates are fired at, a flat head has been found to produce the greatest effect. Velocity of rotation increases penetration.

5. *Best Position for the Centre of Gravity of an Elongated Shot.*—Many opinions are held with respect to the best position for the centre of gravity of an elongated projectile; but, on the whole, it would appear that it should be situated very near, or actually in the centre of the figure, for the effect of a wind will then be uniformly distributed over the whole length, and a moderate velocity of rotation will give stability of axis.

Advantages Obtained by the Employment of Elongated instead of Spherical Projectiles.

I shall now proceed to point out the advantages gained by the substitution of elongated for spherical projectiles.

Advantages.—From what has been said it must be evident that the following are the chief advantages:—

1st. Very great accuracy of fire.

2nd. Long range.

3rd. Great penetration.

4th. Small charge, and therefore much saving of powder.

Accuracy.—It has been shown that, except for very short ranges, elongated projectiles are fired for equal ranges at a less angle of elevation than balls of similar weight (see Table 1); this being the case, the chance of striking an object at a given distance must be evidently greater with an elongated shot in proportion as its angle of elevation is less than that at which the ball must be thrown.

It has also been explained that under favourable circumstances the deflection of an elongated shot fired from a rifled gun is constant for a given range, and always occurs to the same side, and can therefore be allowed for in "laying."

As good practice can now be made at 3,000 yards with rifled guns as could formerly have been obtained at a range of 1,500 yards with smooth-bored ordnance, and with projectiles from the former a 9-foot target may, when 1,000 or 1,100 yards distant from the gun, be struck nearly every time.

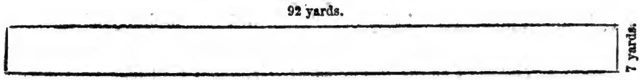
Accuracy of Fire of Guns compared by probable Rectangles.—In order to ascertain the relative precision of fire of different ordnance in a more satisfactory way than can be done by a mere inspection of tables of practice, Captain Noble, R.A. proposed to apply the "theory of probabilities" to the calculation of an area for each particular gun, so that a comparison of the respective areas would at once show the relative accuracy of fire of several guns under trial.* The area, being derived from the results of practice with the gun, represents a space within which there would be an equal chance of any shot fired from the gun striking; or, if a given number of shot were fired, half of the number might be expected to fall within the area.

* Occasional Papers of R. A. Institution, vol. i. page 173.

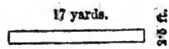
The following areas or "probable rectangles," as they are called, were calculated by Captain Noble from the results of practice at Shoeburyness :—

DIAGRAMS OF COMPARATIVE ERROR.

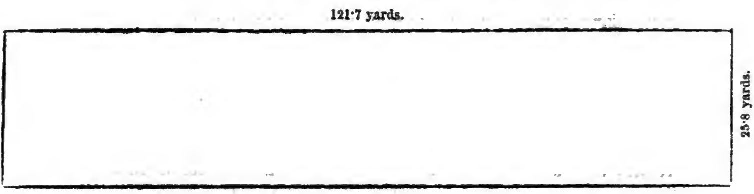
Service 18-Pr. Range 800 yards.



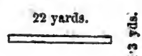
Armstrong 18-Pr. Range 800 yards.



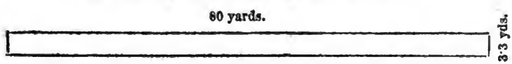
Service 18-Pr. Range 1,760 yards.



Armstrong 12-Pr. Range 1,760 yards.



Armstrong 12-Pr. Range 3,000 yards.



These diagrams show plainly the immense superiority of the rifled guns in precision of fire.

Circumstances favourable to Accurate Shooting.—In order, however, to secure this accuracy of fire, supposing the powder to be of uniform quality, the gun must be fired under the following favourable circumstances, viz.:—

1st. The gun-carriage must stand upon a level and sound platform.
2nd. The distance of the object must be known.

3rd. There must be sufficient time to allow of the gun being "laid" with care.

4th. The air must be still, there being little or no wind.

Deflection after Grazing.—Projectiles fired from rifled guns deviate very considerably after grazing, the deflection varying with the velocity of rotation, the nature of the ground, &c.; and, therefore, in certain cases, as, for instance, in firing at an object of little breadth, this deflection will evidently impair the accuracy of fire, for if a shot strikes short it will most probably ricochet wide of the object. Shell fire has now, however, become so general for almost all artillery purposes, that the deflection of elongated projectiles after grazing is comparatively unimportant.

Very long Ranges, and Circumstances which limit Ranges in Practice.—It is necessary to make a few remarks on very long ranges, and on the practical limits to the ranges of projectiles intended for general service. The following ranges have been obtained from rifled ordnance:—

A 32 lb. shot fired from an Armstrong gun at 33° of elevation ranged 9,153 yards.

A 3 lb. shot fired from a Whitworth gun at 35° of elevation ranged 9,688 yards.

A 175 lb. shot fired from a gun of Mr. L. Thomas at $37\frac{1}{2}$° of elevation ranged 10,075 yards.

All these ranges being obtained at very high angles, over 30°, the "angles of descent" of the projectiles must have been very great, so that the chance of striking an object in this manner would not certainly be worth the powder expended.

The difficulty of judging the distance, of laying a gun upon an object at a long range, and of observing the effect of the fire, also the disturbing influence of the wind during a long time of flight, will confine the ranges of projectiles used for military purposes within 2,000 yards, or perhaps in special cases, when firing at masses of troops, ships, buildings, &c. to 3,000 yards.

It is not to be denied that a random shot may now and then do a great deal of damage at much longer ranges, but artillery fire must not depend on chance, and should therefore be confined to ranges at which tolerably certain effects can be produced.

Saving in Powder.—The charges with which smooth-bored ordnance are generally fired vary from $\frac{1}{6}$ to $\frac{1}{3}$ the weight of the projectile, but rifled ordnance have charges of only from $\frac{1}{10}$ to $\frac{1}{6}$ the weight of the projectile.

Power of Artillery increased.—Combining these several advantages, we find, that by the employment of rifled ordnance with elongated projectiles, the effective power of artillery has been very much increased, and that this increase of power has been obtained with a great saving of time, projectiles, and powder.

The Employment of Rifled Field Artillery.

It will now be necessary to consider the influence of this increased power upon military operations.

Projectile for Armstrong's 12-pounder Field-piece.—The 12-pounder

rifled field-guns (Armstrong) are supplied with only one kind of projectile called the segment shell, which can be used as a shot, shrapnel, or case. When intended for a shot, no fuze is used; for a shrapnel shell the fuze must be arranged so that the shell may burst, like a shrapnel, at a short distance before the object; and for case, the fuze is set to zero, so that the shell shall explode immediately after leaving the bore of the gun. That successful results can be obtained in practice with this shell has been fully established; and it is found that when used as a shrapnel the penetration of the segments is very great.

Comparison of Effects produced by Elongated and Spherical Projectiles respectively.—Now the final velocities of elongated projectiles being, as already shown, so much greater than those of round shot and shell, at all but very short ranges, the penetrating effects produced by elongated shot and shrapnel (or segment shells) must necessarily be very much greater, at ordinary or long ranges, than those caused by similar spherical projectiles. In the case of shrapnel fire this is of very great importance, for one of the chief defects of ordinary shrapnel practice from smooth-bored pieces is, that the penetrations of the bullets are generally very slight at ranges over 1,000 yards.

The ammunition of our field guns has certainly been simplified by the introduction of a single projectile, but this shell would be useless in many situations where the common shell* of the 24-pounder howitzer might do considerable execution; and at close quarters the former, depending for its action upon the proper adjustment of a fuze, would be very inferior to the ordinary case shot, especially as two of these can be fired together.

Simplification of Matériel.—Our matériel has in some respects been simplified by the introduction of rifled (Armstrong) field guns† of only one calibre, but this simplification was adopted in the French artillery, by the Emperor Napoleon,‡ long before rifled ordnance were used.

Peculiar Circumstances affecting the Accuracy of Fire of Field Pieces.—It is very difficult to obtain precision of fire in the field for the following reasons:—The gun-carriage rarely stands on even ground, or on exactly the same ground twice. The difficulty of judging distances and of laying the gun is very great, for the objects are generally moveable, and are frequently obscured by dust and smoke. Haste and carelessness in laying the piece are often unadvoidable when uncovered guns are served under a heavy fire.

Results which can be practically attained with Rifled Field Pieces.—We must not therefore expect the astounding effects often said to be obtained on targets at experimental practice, but must be content with the attainment of the practical advantages that have been pointed out. At the commencement of an action, or in annoying reserves or troops at a distance of even 2,000 yards, very great effects may doubtless be produced with the projectiles of rifled field guns. At ranges of 1,000 or 1,500

* The 24 lb. shell contains 13 oz. of powder; the 12 lb. segment shell only 31 drs. just sufficient to open it.

† A light 12-pounder gun of 6 cwt., carrying a 9 lb. projectile, has lately been introduced for the Horse Artillery.

‡ When President.

yards, they may be confidently expected to do fearful execution among compact bodies of troops, and to dismount an enemy's field guns. At very short ranges up to 300 yards, the fire of smooth-bored field-pieces will do as much, if not more execution, than that of rifled guns not adapted for case shot.

It has been sometimes asserted that the increased power of rifled small arms will in future enable them quickly to silence batteries of artillery; but every one who has had practical experience in warfare knows well that riflemen, unless completely covered, will do but little harm, and often even disperse when plied with shell from smooth-bored pieces. So that rifled guns provided with shrapnel or segment shells have little to fear under ordinary circumstances from the fire of small arms. In certain cases—as when men are posted in buildings or when firing from behind parapets—riflemen can undisturbed take deliberate aim, and their fire will no doubt be very harassing at considerable ranges.

The Superiority of Rifled Pieces for Guns of Position.—The superiority of rifled over smooth-bored position artillery will be very great; for, as the pieces intended for position guns are generally used at long ranges, they can be carefully laid—they may sometimes be provided with platforms, and in certain cases with small parapets for cover. The rifled 20-pounder, which is intended for a gun of position, when compared with the smooth-bored 18-pounder, has, besides the greater range, accuracy, and penetration of its projectiles, the following advantages: The weight of the rifled gun is not half as much as that of the smooth-bored piece;* the carriage of the former is very much lighter than that of the latter; the projectiles of the rifled piece are the most powerful, and are fired with only half the charge used for the shot and shell of the smooth-bored gun.

The total weights, gun and carriage, of the 32-pounder howitzer and of the 20-pound rifled gun are about the same; that of the howitzer being rather the lightest. The projectiles of the howitzer are rather more formidable in themselves than those of the rifled gun—for the common shell of a 32-pounder howitzer weighs 24¼ pounds, and has a burster of 1 pound 2 ounces; the common shell of 20-pound (rifled) gun weighs 21 pounds, and has a burster of 1 pound. But the effective power of the rifled gun is very much greater than that of the howitzer, on account of the inaccuracy, short ranges, and low velocities of the shells of the latter. The 18-pounder, weighing with its carriage 74 cwt., is a most unwieldly affair, and could never, unless the roads were good, keep up with an army on the march.

Rifled Artillery for Siege and Garrison Service.

Guns and Ammunition for Siege Artillery.—The smooth-bored and rifled pieces, with their respective projectiles, used as siege guns in our service may be compared by an inspection of the following table.—

* Because the former is made of wrought instead of cast iron.

TABLE 5.—SIEGE PIECES.

SMOOTH-BORED PIECES.

Nature of Gun.	Weight of Gun.	Weight of Carriage.	Charge.	Weight of Shot.		Common Shell. Weight.		Burster.	
	Cwt.	Cwt.	lbs.	lbs.		lbs.	oz.	lbs.	oz.
8-inch . .	52	39½	8	46	Hollow	49	10	2	4
32-pounder .	50	38	8	32	Solid	24	5	1	2
24-pounder .	50	37½	8	24	"	17	8	0	13
RIFLED GUN.									
40-pounder .	32	42½	5	41	0	41	0	2	8

It may be seen that the rifled gun has the following advantages:—The gun is lighter than either of the others, and the total weight of gun and carriage is also the lightest of the four; this is of great importance, for the transport of heavy ordnance is always difficult. The charge of the rifled gun is much less than that necessary for the smooth-bored pieces, and the shell contains more powder than the others. The hollow shot of the 8-inch gun is rather heavier than the solid shot of the rifled piece, but the latter would, at all but very short ranges, have greater velocity, and would do the greatest amount of work ($w\ v^2$) upon a revetment.

The smooth-bored pieces in the table are also supplied with shrapnel, case, and grape, and the rifled gun with segment shells; so that, provided the latter can be depended upon at close quarters (in sorties, &c.), which it is said they can be, a great simplification of ammunition will have been made without any sacrifice of usefulness.

Circumstances favourable to Accuracy of Fire in a Siege.—In a siege, except during a very rapid bombardment, there is plenty of time to lay the guns with care, and as the objects are generally stationary, and the gun-carriages stand on platforms, great precision of fire may doubtless be obtained with projectiles fired from rifled guns. This precision is of the very greatest importance, for in a siege the objects to be struck are often of small extent; for instance, when firing through the embrasures of the fortress at the guns inside them, or in throwing a number of projectiles at exactly the same portion of a wall or parapet.

Power of Siege Artillery greatly increased.—It must appear then from what has been said that the requisite destructive effects upon the ordnance, revetments, &c., of a fortress can now be produced with the projectiles of rifled ordnance in a much shorter time, with a less quantity of ammunition, and at a far longer range than formerly. That this is practically the

case has been proved in a great measure by experiments in England and on the Continent.

Experiments in England.—An account of some experiments carried on in this country to test the respective powers of rifled and smooth-bored guns in breaching masonry at a long range, viz., 1,032 yards, is given in the Proceedings of the Royal Artillery Institution. With regard to these experiments, the Ordnance Select Committee made in their Report the following remarks:—"It appears that, irrespectively of the superior concentration of the fire of the rifled guns, and its consequently greater effect, they actually performed half as much work again as the smooth-bored guns, with the diminished expenditure of iron and gunpowder noticed in a previous paragraph." Again,—"The precision with which the guns could be directed upon any point it was intended to strike gave them advantages with which no smooth-bored ordnance firing from such a distance could compete; and the same circumstances would have rendered it almost impossible to retrench or defend the breach, for the fire might have been continued with perfect safety to the assaulting columns until they were within a very few yards of it, sweeping away all obstacles as fast as they could be laid, and without the slightest interruption from the musketry of the defenders, the battery being quite out of their range."

Prussian Experiments.—An abstract of the Prussian experiments at Julich in 1860 is given in the "Professional Papers" of the corps of Royal Engineers. The conclusious drawn from these experiments were: "That rifled ordnance can be employed advantageously for firing at a covered object, not visible from the battery, at longer ranges than smooth-bored pieces; that reduced charges may be used successfully with projectiles from rifled guns; that the effect of the shells from these pieces is so great that no other kinds of ordnance are required for breaching; that 13-pound shells fired from [illegible] rifled guns are sufficient to breach quickly a good wall of moderate strength; that 27-pound shells from the same pieces can destroy in a short time embrasures in the strongest masonry; and that 57-pound shells from rifled guns can breach, with a comparatively small expenditure of ammunition, the strongest masonry."

The 40-pound Armstrong gun fires a common shell, which contains 8 ounces more powder than the above 57-pound shell. The angle at which the shells were fired to breach a block-house that could not be seen from the battery was about 6¼°; so that the angle of descent of the shells would be about 8¼°.

Results in Ordinary Practice.—It is perhaps unnecessary to remark that results equal to the above cannot be expected in actual warfare where conditions are less favourable to precision of fire; but the great superiority of rifled over smooth-bored ordnance for breaching can hardly be doubted. As before observed, the point of an elongated projectile droops during flight, unless the velocity be very low; so that more penetration can most probably be always obtained with elongated than with spherical projectiles fired under similar circumstances.

Ricochet.—Elongated shot, on account of their rotatory motion causing them to deflect after grazing, are certainly not so well adapted for "ricochet" fire as the balls of the smooth-bored pieces. But no artillery officer would, I should imagine, ever resort to firing shot with very low

velocities, so that they may make a couple of bounds in a work, when he can fire these shot as shells, or obtain common shells, which may be exploded after clearing the enemy's parapet. Those who have had much gun practice will, I think, agree with me that it is far better to rely upon the explosion of a shell than on the bound of a shot moving very slowly.

Rifled Ordnance for Garrison Artillery.—In estimating the probable effect of the employment of rifled ordnance on siege operations, we must remember that these guns will greatly increase the means of defence. It is very easy to talk of breaching and enfilading works; but engineers do not generally allow these things to be done without at least a great deal of preliminary work. The effective ranges of guns being increased, lines of defence will be lengthened, revetments will be covered, and every possible advantage taken of the nature of ground to nullify the effects of fire.

Those who served in the first bombardment at Sebastopol must remember that a considerable number of guns were soon dismounted and men killed even by the fire of smooth-bored guns at ranges of 1,600 and 1,700 yards; and it will doubtless be a very difficult thing to establish batteries under a heavy fire of good rifled ordnance. The fire of large segment or shrapnell shells will be the most effectual way of disturbing working parties.

Being an artillery officer, I do not presume to give advice as to the best way of protecting revetments, but I may perhaps be allowed to suggest that they should be covered as much as possible, and that portable iron slabs of requisite thickness, which like Thornycroft's could be easily put together, might be kept in the fortress, and placed when necessary before the part of the masonry attacked.* Iron being so expensive can only be used in comparatively small quantities, and if attached permanently to works here and there the besieger could often avoid the parts strengthened; but if the iron be removable it need not be placed before the point to be breached is known.

Rifled Ordnance in Coast Batteries.—The employment of rifled ordnance for naval warfare is beyond the limits of my subject, and I will therefore only remark that, as regards precision of fire, land batteries possess several advantages over ships, for the gun carriages in the former stand on sound level platforms, while those on board ship rest on an unstable surface, which must greatly interfere with the accuracy of the practice; the ranges would most probably be known to the men in the battery, but not to those on the ship; also that shells produce little effect on parapets or massive walls, compared to the terrible destruction created by their explosion inside a vessel. Now, however, that vessels are being plated with iron, they will be comparatively invulnerable, at least to shells; but it is to be hoped that the safe and rapid movement of our vessels will not be sacrificed to mere security from the effects of fire. An extensive series of experiments have lately been carried on to ascertain the effects produced by projectiles fired from rifled ordnance upon wrought iron of different kinds, but the results have not yet been published.

* We shall thus be following the example of the Ancients, who used to let down bags of wool from the top of the wall to deaden the shock of the battering-ram.

Concluding Remarks.—Having now briefly considered the various parts of my subject, I will conclude by stating my opinion, that the increased power of rifled arms, both muskets and ordnance, will doubtless hasten military operations, on the field or in sieges, but that I see no reason for change in the employment of the three arms of the service, each being as necessary for its own peculiar work as it has ever been. It will now be necessary to move troops with more rapidity than formerly to avoid the destructive effects of fire; and for the same reason, men must not be kept in masses but in lines, even at considerable ranges. Troops must, however, eventually come to close quarters in an engagement, in an assault, or in any other operation, and the new arms will then be of no advantage to either party. Fortunately for us, British soldiers are possessed of the two most essential qualities of courage and coolness, useful alike in enabling them to remain steady under a heavy fire at long distances, or to make the best use of their weapons in the excitement of close quarters.

Friday, April 25th, 1862.

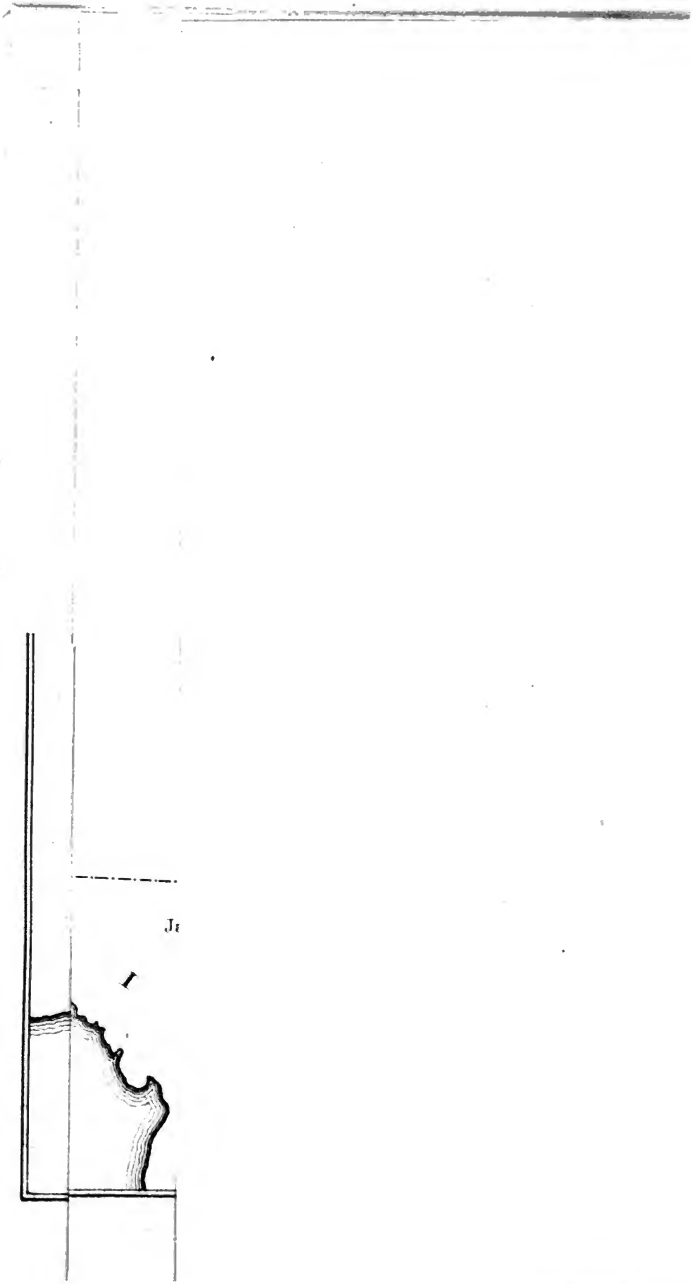
Lieut.-General W. T. KNOLLYS, Vice-President of the Council of Military Education, in the Chair.

MILITARY SKETCH OF THE PRESENT WAR IN AMERICA.

By Major F. Miller, R.A., V.C.

The interest which we naturally feel in the American war has been fed from day to day by the special correspondence of the leading journals, and the ordinary intelligence of daily or weekly papers. But those notices, valuable as they are for the preparation of regular narratives, are apt to confuse as much as they inform us, unless we have the opportunity to treat them as a study. They group together events widely separated from one another both in time and place; they include, in one short paragraph, intelligence from the Atlantic coast and the rivers of the West; they give one day flying reports which they contradict the next, and they republish the same incidents in a new form a month afterwards. When, therefore, I was asked to give a lecture on the subject, I felt that I might do some service in collating these scattered accounts, and in producing a connected sketch from their voluminous materials. Brief and incomplete as the result may be, it may yet lighten the labour of other students, or increase the interest of following the future operations, by rendering more clear those which are past.

I need hardly say that a lecture delivered in this room should be something more than a mere summary of facts. If it treats of military history, it should point out how far principles were vindicated by the results of observing or neglecting established rules, and how any new weapon or any new feature in the equipment of an army influenced its movements or affected its achievements. If this ideal is but little realized, I must, in this instance, beg your indulgence; I could only give an hour or two of the evening to my task, and it is far more laborious to hunt for facts through the extensive columns of daily papers than to study a subject when it is already arranged in books. Moreover, it is much more difficult to describe concisely half a dozen disconnected operations, without definite beginning, without unity of plan, and not yet ended, than to master a campaign directed by skilful commanders and executed by men well acquainted with their work.



This last difficulty will diminish as the war progresses, and there is a far higher interest connected with the present operations than with the desultory marches and petty skirmishes in the first months of the war. When once the men can be relied on for marches and manœuvres, when they are able to do what an army ought, there is no reason why the celebrated campaigns of the Old World should not be equalled in the New. America may yet produce generals of the highest order, but it is to be wished that she should refrain from giving them names in anticipation of their achievements.

My purpose being to touch upon such points only as might be developed into a military history, I pass over in silence the causes which led to the separation of the Southern and the Northern States. But we ought to bear in mind the time at which a rupture was seriously spoken of as not only possible but probable, because we may fairly presume that the military preparations, on one side at least, may be traced back to that date.

It was in the early part of November, 1860, when the success of the Republican party in the contest for electing a President was no longer doubtful, that excitement began to be shown; it gained strength when the result of the ballot was declared; and serious apprehensions began to be felt, which were soon to be fully realized. On the 13th December certain representatives from Southern States had a meeting at Washington, in which they declared that all hope of an honourable adjustment was extinguished, and that their only refuge lay in a prompt secession. Within a few days the declaration was reduced to practice. On the 19th December South Carolina took the lead, and resolved, by a unanimous vote, to withdraw from the Federal Constitution; Florida, Mississippi, Alabama, and Georgia followed her example early in January, and in all these States possession was taken of the forts and arsenals, which were generally left without any military force to protect them. Fort Pickens, near Pensacola, and Fort Sumter, at the entrance to Charleston harbour, escaped this fate from having small garrisons of regular troops. The surrender of the latter was officially demanded from President Buchanan by a Special Commissioner sent to Washington, and, of course, refused.

But, though not yielding in this point, the Government remained almost inactive. The President said that he refrained from sending any reinforcements to a threatened point lest they should be regarded as a menace of coercion, and thus furnish to the disaffected an excuse for an outbreak. Afterwards the Secretary of War announced that reinforcements would be sent to any post if they were demanded by the officer in charge, or if they seemed to be required for safety's sake. With this the people were content ; New York quietly followed her commercial business, and Washington swarmed with place-hunters, anxious only about getting appointments under the new administration. The Seceders, on the other hand, declared their intention of seizing those forts which had hitherto escaped their grasp; they began to throw up batteries, and put guns in position, to enrol men, and prepare munitions of war ; at Charleston, which had become the point of principal interest, an attack on Fort Sumter was daily expected.

Nearly two months passed in this manner. Major Anderson, the officer in command at Fort Sumter, demanded reinforcements, but the Cabinet,

not acting up to the Secretary's announcement, was divided in opinion about sending them, and reports were generally current that the place would be given up. The very day was mentioned. On the 23rd of March the garrison was to be withdrawn, and an opposite rumour that such a step was not quite decided was positively contradicted by a Washington paper.

With this chance of obtaining possession by fair means, the Confederate States, as they began to call themselves, were for the time content; there was too much risk connected with a war to hurry on without necessity such a step as must inevitably cause one. But on the 6th of April there came news that reinforcements of men and an armed squadron had been ordered to Charleston; then their activity broke into new life; 5,000 more men were called out, fresh batteries were thrown up, the supplies of food hitherto allowed to go from the town to the fort were immediately stopped, and Major Anderson was summoned to surrender the place.

On receiving his refusal the attack was ordered. Firing from the batteries began at four o'clock on the morning of the 12th of April; it lasted all that day, and was renewed on the next. Several steamers, tardily arrived with the reinforcements on board, watched the cannonade from the harbour's entrance. At one o'clock the Federal flag was hauled down, and Major Anderson surrendered on easy terms.

As being the first collision in so remarkable a war, this cannonade of Fort Sumter has a claim upon our interest, but the contemporary accounts in the American papers threw over it such an air of burlesque as it will hardly recover in the present generation. Stripped of its historical importance it has but little left; the contest may have been severe and the gallantry great, but one could not resist a smile on learning that a salute which was fired to celebrate the victory, and during which a gun burst, killing two men and wounding four others, did in a moment more serious mischief than was inflicted by the two parties together, during the incessant cannonade of one day and a half.

The news of the Federal troops having been driven by force out of the last point which remained to them between Chesapeake Bay and the Gulf of Mexico stirred up the indignation of the North. The apathy of the people was immediately changed into an intense excitement, and the passive attitude of the Government was succeeded by a due energy. War was formally declared on the next day but one to the receipt of the intelligence; 75,000 of the militia were ordered out by the same proclamation; three weeks afterwards 42,000 volunteers were called for, 22,000 men added to the regular army, and 18,000 seamen decreed for the navy.

These troops were to be furnished in set proportions by the various States, and the demand for them became a test of allegiance; in the north and north-west they were enthusiastically furnished; in other directions they were emphatically refused. The Governor of Missouri denounced immediately and strongly the requisition of troops for such an object. "Not one man," said he, "will the State of Missouri furnish to carry on such an unholy crusade." The Governor of Kentucky used similar language. Tennessee, Arkansas, Virginia, and North Carolina went further; they seceded. In Maryland the Legislature adopted a resolution which condemned the war; the Governor objected to troops from the Northern

States going through Baltimore, and the lower classes actually opposed their passage. A Massachusetts regiment on its way to Washington had to fight its way through the mob, and a Pennsylvanian regiment not yet supplied with arms was driven back from the town. To make the route positively impracticable the railway bridges were destroyed. So determined was the opposition, that levies from New England had to be sent round by sea from New York to the head of the Chesapeake, until (about the 14th of May) Baltimore was forcibly occupied by Federal troops, the railway guarded by sentinels, and martial law proclaimed.

Rapidly as the call to arms was answered on the north side of the Potomac, it could not prevent the loss of two important places which the mere presence of a few hundred men would have saved. On the 18th of April, a body of Virginians went to seize Harper's Ferry, where there was an arsenal with 15,000 stand of arms. Hearing of their approach, and unable to oppose it, the officer in charge filled the buildings with straw, set fire to the establishment, and departed. On the same day the navy yard at Norfolk was likewise abandoned and burnt. The ships lying in ordinary there were fired, or scuttled and sunk; and the only one in commission, the "Cumberland," was towed away. Nearly a year afterwards this ship was run into and sunk by the "Merrimac," one of those which the Federals had tried to destroy.

Washington itself was in considerable danger for a fortnight after the outbreak at Charleston; its escape was due to the enemy's weakness only, for it had no troops in garrison, and its situation was most exposed; on one side was Virginia, which had actually seceded, and on the other was Maryland opposing the passage of troops sent to its aid. However, by the last week in May, militia and volunteers had arrived in sufficient numbers to make it tolerably secure, and the newspapers had already planned magnificent and immediate operations, such as would crush out in a few weeks what they called the rebellion, and re-establish the Federal authority in every State. It is, then, from this time—from about the 1st of May—that the actual campaign may be said to begin; let us, therefore, in anticipation of it, cast a glance at the strength and resources of the rival Powers.

Both being without any standing army—for the few regiments employed to watch the Indian tribes were but a cipher compared to the numbers now required—we may turn at once to the population as an index of the force which might with equal convenience be raised on either side; and, having deducted from the census returns the neutral States and the slave populations, we shall see that by this rule the Federals would send into the field 340,000 for every 100,000 raised in the South. This is, of course, on the supposition that an equal desire to fight pervaded both masses of people; but if there were only half the enthusiasm for the Union as for Secession, still the men of the South, as they buckled on their swords or shouldered their muskets, must expect to be outnumbered in every engagement. Sooner or later, this human tide from the North would be pressing upon them; and where were they to look for means of strengthening their hold or of stopping its progress? Not to fortified places, for inland there were none. Not to greater facilities for moving troops from point to point, for to every forty miles of railroad in the

South there were one hundred in the North; and assuredly not to the artillery and small arms, for in these the inferiority of the South was far more conspicuous. There were but few good weapons in the arsenals and stores, and but few manufactories capable of producing them; without the command of the sea, munitions of war could not be obtained from foreign countries, and the stock might be exhausted quicker than it could be supplied.

These, then, were the circumstances under which the war began. Sixteen States of the North were arrayed against eleven of the South, and three were neutral or divided. The North had, as compared with the South, more than three times the white population, great advantages in equipment, manufactories, and railway communication; an entire command of the sea, and fourteen times the naval resources: its commerce would remain unharmed, except by an occasional privateer; and everything needful might be made at home or obtained from abroad. The South must expect to see its trade ruined, its coasts invaded, its rivers made thoroughfares at the enemy's convenience, the divided States won by force, and then—*then* the resistance she might continue to offer must depend on the unity of sentiment among all classes, and the degree of resolution which survived the trial. She might find in history glorious examples of great invasions being successfully resisted, and of weak inhabitants becoming invincible in the defence of their own firesides; but such a contest is full of bitterness and misery, and success depends on moral qualities, of whose existence we cannot be sure until we see their effects.

I will not pretend to guide you to any conclusions beyond what are based on the rude comparisons I have made; but those I beg you to keep in mind in observing the successive phases of the war.

For six weeks after war was declared the Federal troops were almost shut up in their own capital; it was not till the 23rd of May that they even occupied the suburb of Alexandria, on the opposite side of the river; and, having advanced so far, they remained stationary nearly two months, fortifying the outskirts, spending most of their time in the bar-rooms of the town, and talking always of advancing to Richmond "next week." The world in general, knowing how unfit they yet were for anything but their present employment, watched with more interest the two isolated forts called Pickens and Monroe, both of which were surrounded by Secessionists, greedy of a second bloodless victory.

Fort Monroe, which stands at the entrance to the James River, opposite Norfolk, had been strongly reinforced by the first arrivals from the North, and its commander made an effort to rid himself of his beleaguers. His attempt furnished a curious example of the blunders which may be committed by raw soldiers in the hands of equally raw officers.

Two columns, starting from different points, were to unite at the meeting of two roads, and proceed together against the enemy's position. The march was made at night, and the attack was to begin at daybreak. At the appointed time the first regiment arrived at the fork of the roads, and the second had approached to a hundred yards distance, when, without a word of notice, the first opened fire with artillery and musketry upon it. How such a fatal blunder could have been made seems inexplicable, especially as the artillery fire proves it was not confined to a few

bewildered men. There was no enemy in sight to make a confusion between friend and foe; there could have been no enemy in the direction from which this unfortunate regiment had arrived. The incident is a practical caution against using such troops for the most simply combined movements, and other instances occurred in course of the campaign to show that there was a continual risk of such a mistake.

The rest of the actions in this neighbourhood were principally engagements between coast batteries and gunboats on the Chesapeake, and creeks communicating with it,—engagements too numerous to describe, too unimportant to dwell upon; it was on the other side of Washington that the prospects or circumstances of either side were first influenced by force of arms.

Western Virginia, widely separated from the rest of the State by the parallel ranges of the Alleghany Mountains, is equally distinct in the general occupations of its inhabitants, and, as a natural consequence, in its political opinions. It held to the North; it declared itself against secession from the Federal Government, but it inconsistently passed an ordinance of secession from its own State, and proposed to create itself into a fresh one by the name of Kanawha: in the meantime it invited the presence of Federal troops for the protection and encouragement of the loyal inhabitants. In consequence of this appeal, M'Clellan moved thither from Cincinnati, on the Ohio, and entered on the campaign with energy and good fortune. His first success was at Grafton, a station where the railway to Wheeling joins that which connects Cincinnati with Harper's Ferry and Washington; his next was at Philippa, where he surprised one of the enemy's camps. Turning then towards the hill ranges, he attacked and defeated Colonel Pegram at Rich Mountain, and on the following day had a much more important success at Beverley, where he took six guns, and claimed to have routed 10,000 men, though, more probably, half that number. Coming up with the retreating army at Huttonville, he routed them again, and General Garnett, their leader, was slain. A detached force, acting under his orders in the Kanawha Valley, also had some success at Barbourville. By this series of defeats, suffered within six weeks, secession was crushed in that part of the country, and the State Government established at Wheeling was recognised at Washington as the Government of Virginia.

The cause fared but little better in that mountainous tract which lies between Western Virginia and Washington. Harper's Ferry is at the point where the easternmost ridge, as it is generally shown in maps, runs up to the River Potomac; and the neighbourhood, on either side of the river, was occupied by about 15,000 Southern troops, sent up to help those who had made the original seizure. So important a point was not likely to remain undisturbed, and at the end of May large bodies were moving thither from Pennsylvania. Their point of assembly was at Chambersburg, whence they made an advance in force on the 12th of June; from Washington 6,000 men advanced at the same time, and a column was reported to be coming simultaneously from the West. Not venturing to oppose this combination, the Southerners* abandoned the

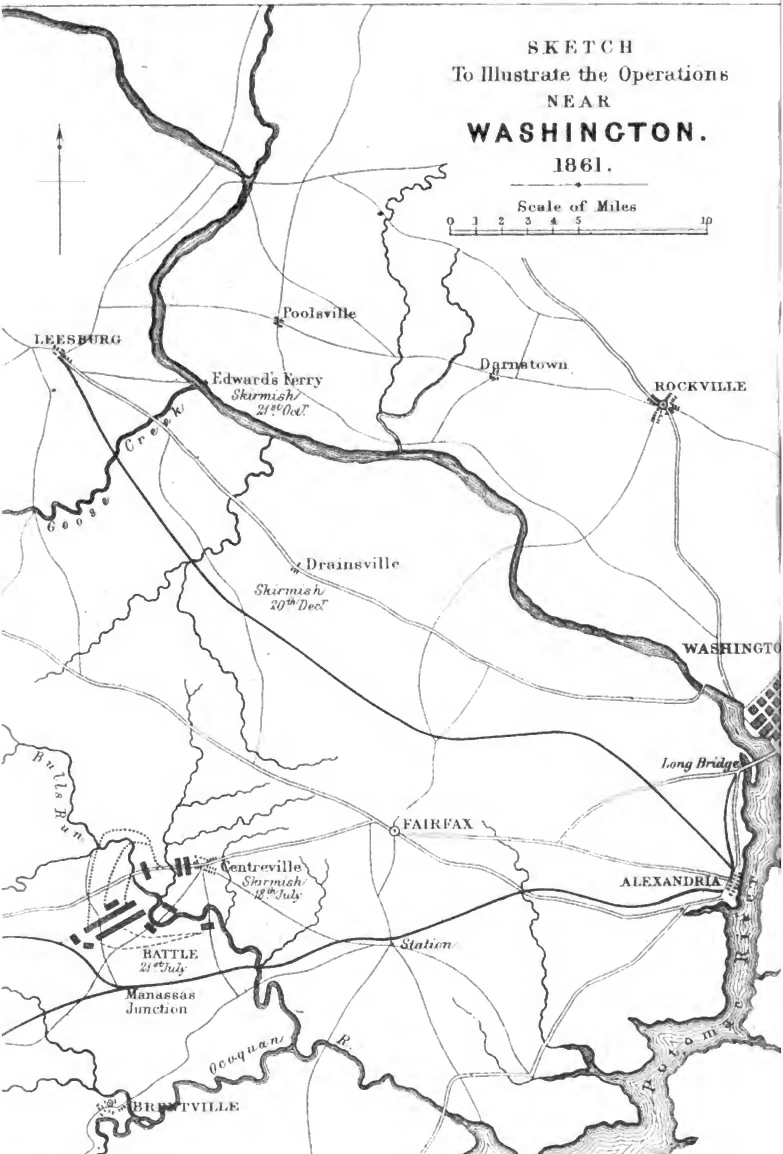
* The term "Southerners" was used throughout the lecture to avoid any misapprehension which might arise from thes imilarity of sound in Federals and Confederates.

place in good time without firing a shot. They took the direction of Winchester, followed by a brigade of Federals under Cadwallader, but before coming to a halt they turned in a north-westerly direction, and encamped at Runker's Hill, twelve miles from Martinsburg. On observing them to take this advantageous position, Cadwallader's brigade retired to the ferry. In this camp the Southerners remained for a fortnight, making one or two successful expeditions, but otherwise inactive. On the 2nd of July they received an attack, great and conclusive on paper, but without any apparent influence on their position, for on the 15th of the month the Federal forces, 15,000 strong, were again advancing upon them at the same place. General Patterson commanded these Federals; he was particularly instructed to threaten the Southerners at Winchester, and prevent them from joining their main body at Manassas, but he turned off to Charlestown, and, instead of holding the field, was said to be busy with plans for rebuilding bridges and re-opening canals. It is only fair to him to say that his division, composed of men organised on truly American principles, was as unsatisfactory a body as a general could be condemned to command. It numbered in all 20,000 men, out of which there were nineteen regiments whose short term of service was up, or would expire in a few days; and fifteen of them, he said, refused to stop one hour beyond that time. A want of transport waggons, a deficiency only too likely to exist, was another excuse offered for him, but the Government had suffered by his mistake, and would not overlook it; General Banks was sent to supersede him.

To his inactivity in not preventing any junction between the Southern troops at Winchester and those at Manassas it was convenient to attribute a great share in the disaster at Bull's Run. Just at the time when he was operating in the valley beyond the Blue Ridge, the authorities at Washington, encouraged by M'Clellan's successes, had given way to the eagerness of the people, and the Grand Army of the Potomac, so called by its admirers, had started for Richmond. You cannot need reminding what the result of that advance was. You cannot have forgotten how the American papers pronounced that the Grand Army might make another triumphal march to Canada as soon as it had reaped the laurels of this; nor how the Grand Army returned to Washington in a panic-stricken mass, officers and men hurrying along without their arms in terror and dismay, shamelessly spreading as they ran the news of their own ignominious defeat. But you may not remember so well the steps which led to that contemptible result, and those I will therefore briefly recapitulate.

The forces which marched from Washington on the 16th of July consisted of 30,000 infantry, 10 squadrons of cavalry, and 60 guns, organised in five divisions of unequal strength. General M'Dowell commanded the whole. The enemy's force was not so well known; his main body was near Manassas, where two converging lines of railway gave him easy communication with all the Southern States; his position was said to be naturally strong and skilfully fortified, but the nature of the works, and the number of the men to defend them, had been artfully kept secret.

On the 18th of July a skirmish at Centreville, magnified by the newspapers into a battle, and construed as a victory because the Southerners retired, raised the hopes and confidence of the expedition; the 19th and


SKETCH
To Illustrate the Operations
NEAR
WASHINGTON.
1861.
Scale of Miles
0 1 2 3 4 5 10
Poolsville
LEESBURG
Edward's Ferry
Skirmish 21st Oct.
Darnatown
ROCKVILLE
Goose Creek
Drainsville
Skirmish 20th Dec.
WASHINGTO
Long Bridge
Bulls Run
FAIRFAX
Centreville
Skirmish 18th July
ALEXANDRIA
Station
BATTLE 21st July
Manassas Junction
Occoquan R.
Potomac
BRENTVILLE

J.R.Jobb

20th were spent in reconnoitering; and on Sunday the 21st the battle was fought.—*(See plan.)*

Between Centreville and Manassas there is a brook or river, called Bull's Run; the two roads by which it could most easily be crossed were strongly held by the enemy, but at three miles up the stream there was an unguarded ford, and another, at half the distance, almost unprotected. General M'Dowell therefore determined to move his main body round by these, to turn the enemy's left, and destroy the railway on that side. On the lower of the two roads a feint was made to distract the enemy's attention; by the other road two brigades advanced over the stream, and joined their line to that of the brigades which had crossed by the upper fords. Up to three o'clock in the afternoon all went well, but till then Beauregard, of the South, had not brought all his force into action. An important order had miscarried. He had intended to make a decisive attack early in the day by that road which M'Dowell had avoided to force, and had sent the necessary instructions to the general on that side; but, learning that nothing had been done towards executing this project, and seeing that his left was already pressed, he thought better to move to the support of the left wing the troops intended for the attack, than to risk a repulse there, which might neutralise his success elsewhere. It was not till this movement was completed that the Federals' determination was put to the proof. The issue was not yet decided, when there came on the field a brigade from that force which General Patterson was to have kept in check (part of it had previously arrived), and a second detachment leaving the train before arriving at the usual station, marched across the country, and fell upon the Federals' right and rear. "Their fire," says General M'Dowell, "caused our men to break and retire, and this soon degenerated into disorder, for which there was no remedy. Every effort was made to rally them, even beyond the reach of the enemy's fire, but in vain; the battalion of regular infantry alone moved up, and maintained itself until our men could get down to the road on the way back."

Observe, I beg, how that sentence illustrates the effect of discipline, and the difference between trained and untrained men; one battalion of real soldiers came forward at need to protect the flight of twenty times their number. But those who fled, and continued to flee, still victims to their panic, when the danger was far behind them, take at least a higher place in our opinion than those who left the ranks that day without striking a blow. The 4th Pennsylvania Volunteers and a battery of the New York Militia turned homewards as the army went into battle because their three months of service had expired. Not overlooked nor unsolicited; General M'Dowell wrote to the regiment, and the Secretary of War appealed to the battery, trying to induce them to remain, if it were but five days longer; but they insisted on their immediate discharge, and on the morning of the 21st they moved to the rear, as General M'Dowell says, "to the sound of the enemy's cannon." A disclosure humiliating but not unprecedented. I could not mention a parallel case out of America, because the conditions of military service elsewhere are so widely different; but in the American War of Independence it occurred, sadly often, that men enlisted for a few months only, refused to remain in arms beyond

that term, however imminent an action might seem, or however important their presence might be. We have seen how another part of this army suffered from the same defect, and it only remains for us to wonder that a system, which General Washington had so strongly denounced, should have been allowed to give further proofs of its utter badness.

General Beauregard stated his total force to be 27,000, and the casualties to amount to 393 killed and 1,200 wounded. M'Dowell reported 481 killed and 1,011 wounded. He estimates the number who actually crossed Bull's Run at 18,000, but that does not include four brigades posted on the roads at or near Centreville. On the whole, we may consider the forces and casualties as pretty evenly divided; but if the missing men in the Federal army could have been accurately numbered on the night of the 21st, a formidable total would have been exhibited.

The Southerners took no advantage of their victory; they merely re-occupied the heights near Alexandria, which they had once before held, and the new alarm which they inspired at Washington soon died away. They certainly cannot be said to have taught their enemies how to conquer, and yet this defeat had a more beneficial effect on the discipline and efficiency of the Federal army than if it had been an easy victory. Taught by the mortification of failure, the authorities saw the necessity of a more active commander and a more strict control; they turned to M'Clellan, as the only general whose ability had yet been stamped with success, and placed him at the head of the army.

Leaving his division in Western Virginia, he arrived at Washington on the 26th, and addressed himself forthwith to the hard task of turning Americans into soldiers. He succeeded well in that respect; the streets of Washington were less infested by idle officers and men, but the campaign was not advanced. Its history for the next six months, in this district, may be dismissed in a few words. The army was confined to the intrenchments round Washington till the 28th September, when the Southerners unexpectedly retired from the advanced position they had held. In moving out to occupy the deserted posts, certain regiments managed to repeat the blunder committed at Little Bethel, and fired upon one another with fatal effect. Eastern Virginia was occupied in November, and some great reviews took place; a few skirmishes, of which one will be noticed by and bye, may also be picked out of the American news, but no division of the army contributed so little to the first annals of the war as that which was called the Grand Army of the Potomac.

In Western Virginia the troops from which M'Clellan had been removed fell under the command of General Rosecranz, and seemed, by the newspaper accounts, to keep up their reputation for activity and good fortune. Scarcely a mail arrived without the news of some gallant skirmish or important victory, but the result of them all was that the little campaign which began at Gawley Bridge on the Kanawha terminated at the very same point; and the neighbourhood of Beverley, where M'Clellan had won his last battle, was the scene of another victory ten weeks afterwards. In short, when the troops went into winter quarters they were no further advanced in the State than they had been four months earlier in the year.

In the north of Virginia there were also many little combats of a kindred nature to those in the West, similarly described and equally extolled, but foiled by one reverse which could neither be passed over in silence nor transformed into a victory. Being of more importance and interest than the rest, it claims a few moments of your attention. At Leesburg, 30 miles north-west from Washington, a part of the Southern army was stationed, the Potomac River, a few miles off, separating the outposts from those of the Federal division under General Banks, whose headquarters were at Darnstown—(*see plan*). Under him was General Stone at Poolesville, and Colonel Baker commanded the regiments nearest to the river. To this officer General Stone sent a sudden and laconic order to make a dash at Leesburg. Over the river, swollen with heavy rains, 400 men were sent by night in a few small boats; in the early morn they pushed on boldly, but rashly without support, to Leesburg, found the enemy there, and were quickly obliged to return to the river side. Small reinforcements were sent over to their help, and in the afternoon Colonel Baker came to take the command. The Southerners were superior in number, but had no artillery; the Federals had three guns, but the ground was unfavourable for their use. About four o'clock Colonel Baker was shot, and the Federals, gradually despairing of driving back the enemy, began to seek means for their own retreat. And then came the terrible scene which cannot fail to come when the rushing current of a wide river has to be crossed by beaten men with insufficient means at their disposal: such scenes have been often described, and only repeat themselves; let figures tell the story of this. Of 1,800 men who had left the Maryland side, one-third were left on the opposite bank, the three pieces of artillery were lost, and in one regiment there were said to be only two swords, and not one musket, left.

So great was the alarm created by this disaster that the Federals might have suffered seriously if they had been attacked immediately in that part of the line; but except that the Southern troops at Leesburg were reinforced, as if such a thing were intended, the action at Edward's Ferry (or Ball's Bluff) made no difference in their relative situations, and within a couple of months a chance skirmish took place between Leesburg and Washington, in which the fortune of war inclined to the opposite side. The scene of the encounter was at Drainesville, and the contest was occasioned by sending an expedition to take a quantity of forage which the Secessionists had collected there. The action was sharper than usual; on each side a brigade with some artillery was engaged, but that of the Federals was stronger than the other, and the affair lasted but one hour. Forty of the enemy were found dead on the ground, and fifty loads of forage, with two ammunition waggons, were brought back in triumph to Washington.

In the same column of the "Times" with the official report of the Drainesville engagement there was also the announcement that elsewhere a camp had been surprised, and the Southerners in it, with their arms, waggons, and tents, captured by hundreds. At first sight it seemed to form part of the operations in or near Virginia; it was really as independent of them in plan as it was remote in situation, and to the country where it happened I must now invite your attention, a country as far from

Washington or the banks of the Potomac as the coasts of Africa or the boundaries of Russia are from our own metropolis.

Where the waters of the Ohio unite with the Mississippi, after inclining towards one another for 150 miles, public feeling is divided between attachment to the Union and determination to secede. Kentucky and Tennessee on the east, and Missouri on the west, long halted between the two opinions, and the southern counties of Illinois, above the meeting of the rivers, were affected by a Secessionist tendency, though they had not weight enough to control or influence the policy of the State. Cairo, therefore, as its most southern point, was early occupied by Federal troops, whilst Randolph, below the doubtful States, was the headquarters of the Secessionist force. Thus stood the two parties when Fort Sumter fell, and President Lincoln called for troops to crush the rebellious South. In Missouri the Governor characterised the requisition—I quote his words—as "illegal, unconstitutional, revolutionary, inhuman, and diabolical;" but there were many people ready to apply equally strong epithets to his own despatch, and a contest in the State immediately began. Forces were raised for the cause of the Union; their appointed General, Lyon, refused to disband them at the Governor's order, and, when the State militia was called out to enforce the command, he began the campaign by attacking and defeating a part of it at Booneville.

His personal career was but a short one. The Governor's troops, commanded by General Price, having moved towards the south-west, he followed in pursuit. His van-guard engaged them at Carthage on the 5th of July, and his main body came up with them on the 10th of August, near Springfield. An action ensued, of which the result was important, and the description curious. It begins by telling how 8,000 Federals attacked 23,000 Southerners, spread slaughter and dismay in their ranks, killed two of their generals, and destroyed all their tents and waggons: it ends by a brief remark that the very army which had done so much had retreated several miles, and might be considered *safe*. And by degrees these facts became evident, that it was the Federals who were defeated; that they lost a gun; that General Lyon was killed on the field, and that St. Louis itself was in danger of capture.

Instead, however, of attacking the head-quarters of the Federalists, General Price took a northerly direction, and shortly appeared before Lexington, on the Missouri, where he was joined by a body of troops from the neighbouring state of Kansas, and fresh levies raised by Governor Jackson. An entrenched camp near the river was occupied by 3,500 Federals; on this, when his force was fully assembled, General Price opened fire; 1,500 men coming to its relief from Richmond, in the north-west, were easily driven back; and on the evening of the 20th September the place was surrendered.

Its loss was angrily felt by the Federalists; the whole garrison, with artillery, stores of considerable value, 900,000 dollars in money, and an important position, had been allowed to fall into the enemy's hands; strong indignation was expressed against General Fremont, who commanded at St. Louis, for omitting to send such reinforcements as would have prevented it, and preparations were made to recover the post. Fremont himself started on this expedition, but by the time he reached Jefferson City, Price

had retired towards the town of Independence, whence he soon returned to the south-west of the State. The Federals followed him in several divisions by various routes, and on the 25th October there was a skirmish between them at Springfield, but Price was expecting to be joined by a division under General M'Culloch, and till then it was not his interest to fight a battle. Even after the junction he continued to retire until he reached the boundaries of Arkansas. About that time a change took place in the command and movements of the Federal army. General Fremont was superseded by Hunter, and the divisions in this part of the State began to retrace their steps. Price in his turn became the pursuer, and was back at Springfield by the 25th November.

During the winter months of December and January both parties remained inactive—the Federals did not claim a single victory.—February had arrived when they began to assemble their divisions preparatory to attacking Price, who was still in his old quarters at Springfield. When they advanced upon him he repeated his old tactics of retiring towards Arkansas—there the fighting began. Whether he was brought to bay, or whether he voluntarily took the offensive, I cannot say; but there was a series of engagements extending over several days, and comprising an important battle at a place near Bentonville, called Pea Ridge. In this, M'Culloch, one of Price's generals, was reported to be killed and the Southern force entirely dispersed, but I have seen no official despatch or authentic account of the battle; and by the last intelligence the Federals had fallen back into Missouri, which is no sign of success, whatever policy may have dictated the step. Many of these victories assume very small proportions when measured by the results which attend them.

You will do well to remember that all our intelligence is derived from Northern sources, and the accounts of one side only are never a safe authority. In any war we can only approach the truth by carefully weighing the statements of both parties, which, in this one, are beyond our reach. The case of the Southerners is that of the lions in the fable, who were always shown in pictures as being killed by man, because lions were never the painters.

The engagement to which I referred on beginning this account of the war in Missouri, was one of those disconnected affairs with which every civil war abounds. Here they pervaded the whole State; in the north part they occurred near the Mississippi, or along the railway which connects the western interior with the great lakes of the North. In the south-east the scene of them was near Fredericton, the point in dispute there being apparently the command of that unfinished railway which is to give the town of St. Louis a direct communication with Memphis, and thence with the Gulf of Mexico and the Atlantic Ocean. Also from the frontiers of Kansas there were occasional tidings of conflicts, and along the banks of the Lower Mississippi parties of Federals from Cairo occasionally landed, fought, and returned whence they had set out. The Federals were undoubtedly stronger in arms, but their force was not applied with corresponding success. It was in Missouri as it had been in Virginia: the want of an established military system retarded the development of their resources, and impeded the application of their strength; it made the excellent weapons with which they were armed comparatively

useless in their hands; it put the wretchedly-equipped levies of the South on almost equal terms with their adversaries; and, had not the vast numbers of the Federal army been assisted by an irresistible naval force, another season might have passed away without bringing any return for the profuse military outlay of the war. On the sea coast, where the broadsides of the ships could overpower the batteries on land, bodies of Federal troops had lodged themselves; in districts where any sympathy was shown by the people the superiority of the Federal strength had also made itself felt; and now an expedition was being prepared in which both these allies would be brought into play. Starting from Cairo for the invasion of Kentucky and Tennessee, and following the course of two navigable rivers, it would be accompanied by iron-plated gunboats, would be assisted by all the water transport of the country, and would penetrate two States whose inhabitants were partly favourable to its success.

For a long time these two States had enjoyed an immunity from the scourge of the war. Kentucky professed a strict neutrality; refusing to furnish troops to the North, it equally declined to secede with the South; professing a desire for nothing but peace, it protested against either of the combatants occupying its soil or even crossing its territory. Tennessee, more committed to secession, was secure from hostilities so long as the protests of Kentucky were respected; but at the beginning of September the Southerners presumed to occupy Hickman, and the Federals Paducah: both disregarded the Governor's injunctions to quit, and at once Kentucky became a new theatre of war.

The Federals were along the Ohio River, the northern boundary of the State, posted principally at Cincinnati and Cairo, with a footing in the State at Louisville and Paducah. For them a perfect network of railways communicated with all parts of the rear. For the Southerners there were only two lines, leading from the Ohio River to the interior of the country; one through Nashville, the other through Humboldt; but the natural features which had prevented the construction of railways might serve well in a defensive campaign, and the Cumberland Mountain range, which traverses the district, might prove a useful ally in time of need.

Columbus on the Mississippi was for a time the principal Southern camp; but according as the Federals threatened to advance from Henderson, Louisville, and Cincinnati, Bowling Green in the centre was occupied by troops under General Buckner, and the western part by others, under General Zollicoffer. The latter was the first to be engaged. The Federals arrived in his neighbourhood early in October, and on the 21st he made an unsuccessful attack upon them. Again, on the 13th of December, he was reported to be moving from Cumberland River to Somerset, and a fight was said to be imminent. On the 19th of January he fulfilled this expectation by again taking the initiative. How he had employed the interval of a month between places which are only twenty miles apart, I cannot explain; but the immediate inducement for the attack was that the enemy's force had divided—one part remaining in camp, whilst the other made a flanking movement. To seize this opportunity sounds both bold and wise, but the result was highly unfortunate; General Zollicoffer himself was killed, his men were driven back to their camp, and, being pursued and attacked there, fled again, leaving behind them

10 field guns, 100 waggons, 1,200 horses, and a great quantity of small arms and stores. General Crittenden, next in command, rallied them at Monticello, but soon made a further retreat, and the Federals followed them up.

This defeat amounted to a disaster, so serious an aspect did it bear from every point of view. The loss of so much matériel was a serious blow to an army so imperfectly equipped. The loss of the position and disorganization of the troops exposed the flank of their main line to be turned by an enemy numerous enough to do so without risk, and the repulse itself had a disheartening effect on their courage, coming as it did in the wake of the long fruitless struggle in Missouri, and their recent defeat at Drainesville, in Virginia. I was near adding to the list another battle lately fought in the corner of Kentucky, near Pikeville, a hundred miles from Somerset, by which a Brigadier General Nelson suddenly became famous. The Confederates captured and slain by his skill were, it appeared, exactly 2,415, including two generals; and I should have liked to describe the wonderful manœuvre—for it was a wonderful one—by which he was reported to have secured the result.

But on coming to the newspapers of a fortnight's later date, I had to strike out the notes I had made. "Somebody," as Mr. Russell said, "had blown the general's trumpet a little too loud and a little too long." There were 25 killed—not 400; there were 50 prisoners instead of 2,000; and the battle was without a manœuvre at all; "but it was a glorious victory," an American paper still said, "and has rejoiced the hearts of the nation and greatly cast down its enemies." Glorious or not (and I should say *not*), any success was valuable in that part of the State whilst General Thomas was moving from Somerset towards the Cumberland Mountains, and troops from Cincinnati and other points on the Ohio were marching southwards for Bowling Green.

At this place, the junction of two railways, the Southerners were in considerable numbers, under General Buckner. Further west they were stronger still; 40,000 men were said to be at Columbus, and an attack upon Paducah was hinted at, but there was no fighting beyond a few skirmishes, until General Grant's expedition entered the State.

With nineteen regiments of infantry, four of cavalry, and seven batteries of artillery, an important addition to the troops already in Kentucky, General Grant arrived at Paducah on the 15th January. A flotilla of gunboats, prepared to steam up any navigable river, was ready to take part in the expedition, and their heavy guns, protected by plated sides, were more numerous and far more formidable than the field artillery of the force. Fort Henry, against which the first operations were to be directed, was an earthwork on the river Tennessee, a little outside the boundary line of Kentucky; thrown up by the Federals during the previous summer, it had not strength of construction to resist a long attack from superior forces, and, commanded by higher ground on both sides of the river, it could only be regarded as an useful outpost, to be given up, when attacked, if it could not be adequately supported. Reinforcements to the amount of three or four regiments were sent thither when it was first threatened, but these were barely enough to guard a retreat; they encamped outside and retired without fighting; only sixty men remained inside to fight the guns,

which should have had twice or thrice that number for their service. When, therefore, the seven gunboats opened their fire, they reduced the place in one hour and ten minutes without any aid from General Grant, though in doing so they suffered more than twice the loss they inflicted on the garrison, and one was utterly disabled. A general, named Tilgham, and the sixty men, were taken prisoners; ten heavy guns, ten light ones, and seventeen mortars were found in the place, and for what purpose the mortars could have been placed there I am at a loss to conceive. The fort itself was flooded by the rising of the stream, and had to be abandoned within a week, a sufficient proof of the badness of the site.

In the meantime General Grant had moved across from the Tennessee to the Cumberland River, which here runs in a parallel direction at ten miles distance. At Dover, on the Cumberland, the Southerners had entrenchments of considerable extent, held by a considerable body of men; and they knew that much depended on the firmness of their stand here. Long before the fall of Fort Henry, before even the expedition had left Cairo, a Richmond paper had noticed the threatening aspect of Buell's formidable force near Bowling Green, and had clearly pointed out the disasters that might ensue if this point were forced. Since then Thomas had defeated Zollicoffer in the east of the State, Mitchell's division had advanced to Bowling Green in the centre, and thirty-five regiments, aided by gunboats, were ready to attack their stronghold in the West. The crisis had become more serious; to meet it they had sent for the general reputed to be their most able commander, Albert Johnson, and had brought Beauregard, the victor at Bull's Run, with 15,000 men, from Virginia to Kentucky: neither of these, however, were at Dover when the fatal day arrived.

The interval between the 6th February, when Fort Henry was taken, and the 15th February, when the entrenched position at Dover, called Fort Donnelson, was attacked, was spent in marching over the country and investing the place. At daylight on the 15th the action was begun by the opposite side; the Southern generals, finding that they were surrounded by the enemy, cut off from supplies, and imperfectly defended by their earthworks, resolved to take the offensive, hoping to obtain at least such a success as would enable them to open a gap for retreat through the investing lines. For a time they were successful; they drove back the right wing on the centre, and had managed to capture an entire field battery; but, whilst so engaged, part of their own entrenchments had been stormed and won, and their efforts to dispossess the new occupants were of no avail. The loss of this point, which commanded the rest of the line, made it doubtful whether they could hold out one more day; but retreat was again as difficult as it had been before the sortie, for the enemy had reoccupied his former positions, and all the day's labour had been thrown away.

A second council of war was therefore held, and a very remarkable course was adopted. Of three generals, Floyd, the senior, thought it useless to fight, but vowed he would not surrender; Pillow, the next, was in favour of fighting; Buckner, the third, preferred a surrender to every other course. That generals in council should hold opposite opinions is not extraordinary; but never, I should think, has any difference been

terminated or reconciled like this. General Floyd gave up the command to Pillow, on condition of being allowed to retire with his own brigade; Pillow in his turn made it over to Buckner on a similar condition, that his own personal movements should be left unfettered; and Buckner, then able to act on his own opinion, surrendered the whole force on no condition at all. This triple transfer finished the episode of Fort Donnelson.

The Federals claim to have taken 13,300 prisoners, and a list, purporting to be official, gives by name the regiments, twenty in number, to which they belonged. General Pillow, however, reckoned the whole force at only 12,000, of whom many were killed during the action, and one brigade escaped. The discrepancy is large. The escape of General Floyd's brigade also requires explanation, for a single gunboat of the flotilla might have prevented it, and three or four thousand men could hardly have been embarked without being detected by a reasonably watchful enemy.

On the day that the fate of Fort Donnelson was settled, Bowling Green likewise was occupied by the Federals. That the division there should soon unite with Grant's, that Nashville, which lies defenceless on the Cumberland River, should be taken without resistance, and that the Southerners should choose some point in the less accessible country on the south or south-east for their next contest, was only to be expected. The question was, how far the Federals could dispense with the aid which the navigable rivers had hitherto offered them, both in convenience of transport and in power of artillery. At the time that I was writing this, a month after the news of Fort Donnelson's capture had arrived, the intelligence from that part of the country had dwindled to nothing, the advance was in abeyance; let us take the opportunity of tracing the various expeditions which have been made to vulnerable points on the Atlantic coast.

They may be distinguished as Butler's, Sherman's, and Burnside's. Butler's, the first, mustering 4,000 men, and backed by men-of-war bearing 100 guns, left Fort Monroe on the 26th of August, and appeared before Hatteras, or Ocracoke Inlet, the evening of the 27th. This channel, the entrance to an interior sea, was guarded by two small forts. To make a combined attack upon them by land and sea, the disembarcation of the troops began, but a heavy sea stopped it, and the men-of-war opened their fire without waiting for it to be completed. Considering that the larger of these forts embraced only two-thirds of an acre, and that both were mere field-works, mounting only 17 guns between them, we need not be surprised that they soon succumbed. The smaller was evacuated the first day of the attack, the second capitulated early next morning, and 700 prisoners, with 1,000 stand of arms, were included in the surrender. The casualties in them amounted to about fifty killed and wounded; on the other side there were none, owing to the troops not having been engaged, and the ships having judiciously kept as far off as possible. The fleet soon departed. The troops and a few gunboats remained to hold the place, but nothing occurred of sufficient importance to be mentioned here; the conquest was barren of results; it did not stop the Southerners, as was intended, from navigating those inland seas; it did

not serve as a base for further operations, and its occupation was attended with great sickness in the winter months.

The next expedition, Sherman's, was on a larger scale. It was composed of fourteen regiments and one field battery; its escort was twenty-seven men of war, with 400 guns, and its equipment included everything necessary for fortifying the point at which they might land. That point was a secret; in reality it was not fixed, but was left for circumstances to decide. Port Royal was eventually chosen, and the ships weighed anchor on the 29th October.

A severe storm on the way protracted the passage, scattered the fleet, and wrecked some of the transports. Arrived at Port Royal, the means of disembarking the regiments were found to be so much reduced, that the attack on the forts at the harbour's mouth was left to the ships alone. The bar which threatened to prevent the entrance of the larger men-of-war having been safely passed the engagement was opened. In four hours both of the principal batteries were silenced, and the Southerners' gunboats lying behind them, unable to render any efficient help, had dispersed to seek their own safety.

The white inhabitants of the neighbouring town of Beaufort fled; the negroes remained, but there was as little aid to be got from the latter as there was Union feeling to be found in the former. The first use to which Port Royal was applied was to send from it those stone-laden ships which were to be sunk at the entry of Charleston Harbour, to close it, not only for the present, but the future,—to fill it and choke it for evermore. You remember, I dare say, what indignation was expressed in Europe at such a deed, and you may remember that, to turn away the reproach, the New York papers pleaded that they only wished to bar the entrance which they could not closely blockade, and that another, in some respects better, channel remained open as a proof of their forbearance.

It is true that another channel did remain open, that they had forborne to close it; but the Admiralty chart suggests for that forbearance the charity which begins at home. The bar which stretches in front of Charleston is crossed by the main channel at six or seven miles from the forts at the harbour's mouth; but it is crossed by the other channel at a few hundred yards only from the northern fort, and the deep water outside widens like a fan, so that obstacles to prevent the passage of ships must be sunk at that one point, or not at all. Whilst, therefore, in one case they could work their will in safety, in the other they must approach under the point-blank range of heavy guns. Judge for yourselves how far this may have effected the safety of the second channel.

To return to Port Royal. At the end of November Tybee Island was occupied, by which the entrance to Savannah was commanded, and Fort Pulaski might be attacked: it has been attacked, is still under attack, but has not yet (10th April) fallen. In March, the activity which pervaded the whole war extended itself to this expedition, and two other places on the coast, Brunswick and Fernandina, each the terminus of a railway, were likewise seized; here we must leave it, that we may bring the narrative of General Burnside's expedition down to the same date.

This expedition, starting, like Sherman's, for an unknown destination, sailed from the Chesapeake on the 11th January, just at the time when

Grant's force was assembling for the invasion of Tennessee. On the 15th it entered Hatteras Inlet, and on the 7th February it made an attack on the island of Roanoke, a spot already known to American history as the place where the first discoverers sent out by Raleigh were hospitably entertained by the Indians, and where the earliest settlement was made in the State whose capital now bears his name. The island, which commands the channel between Albemarle and Pamlico Sounds, is about twelve miles long, and was defended by 3,000 men, six batteries mounting forty-two guns, and eight steamers carrying two guns each. The Federals attacked it by land and sea. They were, as usual, superior in numbers, and the Southerners, as usual, had no defences of sufficient worth to restore the balance of strength. Their main body rested on an earthwork into which a man might walk, and which was attacked on three sides at once; their retreat was limited by the extent of the island, and the result need hardly be told. Everything was lost: the gunboats indeed retired to Elizabeth Town up a creek on the north side of the Sound, but were followed and destroyed there.

Newbern, which is also within reach of the navy, fell, on the 14th March, after very similar operations; Beaufort and Washington have been taken uncontested. Many, therefore, are the points at which the Federals have now effected lodgements in the rival republic; I will briefly describe their present position (24th April). In Western Virginia they occupy the Kanawha Valley, and most of the country west of the Alleghany Mountains. In Northern Virginia they have begun to advance down the valley of the Shenandoah (an advance which occasioned the late action of Winchester), and have occupied the country for some distance from Washington towards Richmond, so far as it is not defended by the enemy.

On the eastern side, near Fort Monroe, the army under General M'Clellan (no longer commanding in chief the whole of the forces) has safely landed from the boats which brought it down the Chesapeake, and is about to attack a formidable Southern division at Yorktown. At Beaufort (North Carolina), Fort Macon, held by a few hundred men, will probably soon fall into the Federals' hands, and Fort Pulaski, at Savannah, surrounded and famishing, is said to have already offered a surrender.* Brunswick in Georgia, Fernandina and Jacksonville in Florida, have been occupied by the Federals. Fort Pickens has never been taken from them, and a formidable expedition of land and sea forces is engaged in the reduction of New Orleans. How it fares with them we are not allowed to know; a fortnight has passed since we heard of their being in the immediate neighbourhood, and so entirely is the press in the power of the Government that silence cannot mean success, whilst it may imply anything between victory and disaster.

Far up the Mississippi, beyond the borders of Tennessee, the Federals have skilfully captured the island above New Madrid, called No. 10; and in the south of the same State, close to the point where the River Tennessee enters Alabama, the greatest battle ever fought in America has just taken place. It was only on Wednesday last that the details were pub-

* News of its capture arrived a few days afterwards.

lished, and I need not enter into them. The Federal troops engaged were a part of General Grant's force, moved thither from Dover and Nashville, supported by those who had come through the middle of Kentucky from the Ohio. The Southerners had been collected from Pensacola and various other points; their arrangements seem to have deserved success, and I regret to see that among their killed was the general reported to be their most able commander, Albert Sydney Johnston. His loss will be a blow to their confidence, which they can ill afford to suffer; and by his death America loses a good soldier who might have raised her military reputation.

From Eastern Tennessee we have had no news of importance since Nashville was taken; Kentucky I believe to be exclusively occupied by the Federals, and Missouri to be generally in their hands.

If I have taken no notice of the combat between the "Monitor" and "Merrimac" it is because the result has not influenced the military progress of the war; its interest depends on considerations which would only distract your attention from the general history; and to treat it as it ought to be treated would detain me too long. Already the narrative has extended so far, that I have but little time to touch upon the wide and inviting field of review, and the following brief remarks are all that I can venture to offer.

With immense manufacturing resources, extensive commerce, and freedom from public debt, the Federals had at the outset everything that a nation could want for the purposes of war, *except* an army. For want of it their capital had once been burnt, but during the fifty years which followed they encountered no foe more formidable than Texas and Mexico, and, far from desiring to change their military system, they held it to be the best that they could maintain. Their militia was reckoned at three millions; their regular army numbered seventeen weak regiments, whose companies, employed in guarding the interior States against Indian forays, did not form one single brigade of the troops sent into the field. It was, therefore, with untrained men, inexperienced officers, and generals snatched from civil pursuits, that the Federals talked of conquering forthwith the seceded States. If they had fulfilled one hundredth part of their task in the time they named the world would have been amazed. The professional soldier's life would, indeed, be wasted, and his occupation might well be gone, if thousands of men thus hurriedly called under arms could be marched and manœuvred at will. That they could be thus handled no disinterested person was sanguine enough to suppose, but nothing less than an unmitigated failure like Bull's Run would have convinced the American journalists that their militiamen were not (to use their own words) "better than French soldiers."

Of the interior state of the Southern army we have heard little; but the glimpses which Mr. Russell obtained and communicated are in accordance with what we might expect, and the council of war at Fort Donnelson bears similar testimony to its unmilitary condition. From the Northern side the intelligence has been ample, and abounds in incidents which illustrate the want of discipline; they embrace every variety of disorder, from the careless use of arms, and the independence of sentinels on duty, to attacks on officers and mutinies in regiments. And it is not

surprising that it should have been so; the private soldiers required a judicious rule, firm but temperate: how much judgment or temperance was there amongst the officers? What could be the state of a regiment in which (according to a New York paper) the major was drunk in his tent, the lieutenant-colonel was drunk on parade, and the colonel being tried for drunkenness, all at one and the same time? The paper may have added to the truth; but think how far the evil must have gone for such a tale to be told. After the first three months there were many changes among the officers, and another American paper doubts whether, out of 225 who had lately left, 25 had quitted their regiments without dishonour. Such was the judgment of their own press, and I can set nothing against it. Some few officers there were who had gone through the military college at West Point, and we may hope that there were many honourable exceptions to the general rule; but the majority earned for themselves, by ignorance and bad example, a most evil reputation in the early part of the war. When we think how much this must have checked the improvement of the army, we need not wonder that the main body did so little. A general would not be blamed for delaying an attack until his numbers were equal to the emergency; and want of discipline is a more dangerous failing, a more fatal weakness, than want of men.

I can well understand that the arms of the Federals should be excellent, their matériel of artillery magnificent, and their appearance on parade imposing; but the internal state of an army is not to be learned by seeing it march past at a review; and it seems to me that so great a change as would transform the Federal forces into a disciplined body *must* require a great space of time.

There are still other things to be weighed and considered before we blame either side for not showing us more operations on a large scale. Much of the country is still so covered with wood as to be unsuitable for great manœuvres, and the want of well-made roads would utterly prevent long marches, except in dry weather, or on routes where the railways could lend their aid. That roads should be few is only natural, considering that the population is still thin; but it is singular that in America they have been outstripped by railways, and iron tracks are now the first good communications made between rising towns. In Missouri, for instance, there are 720 miles of railway, whilst, a few years ago, there were only five macadamised roads, which led from St. Louis a few miles towards the interior; but it is on roads and not railways that a general must rely in his first invasion of an enemy's country.

As the country and the roads influenced the movements, so would the nature of the contest give a character to the earlier plans. In every civil war there is sure to be one or more districts where the inhabitants are divided in feeling between the combatants, and to establish one party in a superiority is the object of the first expeditions and encounters. Hence the operations in Western Virginia, Missouri, and Kentucky. Next in such cases is likely to come an attempt by the stronger side on the capital of the weaker, aided, if possible, by diversions on scattered points of his frontier. From this general maxim, rather than strategical plan, the first advance towards Richmond, and the expeditions of Burnside, Sherman,

and Butler have sprung. The invasion of Tennessee from Cairo, and the simultaneous advance through Kentucky from the Ohio are more nearly allied to the art of war, but still to be traced to the sympathies of the inhabitants.

Wherever the opponents meet on neutral ground, the weaker in arms and numbers cannot fail to be worsted, unless led by a superior skill which we can hardly expect to see. In the after part may come a period when strength may begin to rise out of the results of weakness; once out of reach of the formidable artillery, which is unendurable if it cannot be stormed or silenced, activity and daring may outweigh numbers—vindictive despair may compensate for inferiority of personal weapons—or the passive resistance of a united people make victory fruitless and subjugation impossible.

The Southern States are now approaching a crisis, which has only been hitherto deferred by the inability of the North to wield its weapons of offence. If the Confederacy of the South is not prepared to stand, it should not have been hasty to rise; if it cannot be patient to endure, it should not have been bold to strike. I see no reason to doubt that its spirit is true, but future events will speak for themselves: having explained to the best of my ability those which are past, my task is over; I have only to thank you for your attention, and to conclude by wishing you a better guide to the further scenes of the American War.

Friday, May 23rd, 1862.

MAJOR-GENERAL SIR RICHARD AIREY, K.C.B., Quartermaster-General, in the Chair.

THE VALUE OF A GYMNASTIC TRAINING TO THE SOLDIER.

By ARCHIBALD MACLAREN, Esq.

When it was proposed to me that I should do myself the honour of reading a paper on this subject before the members of this Institution, I for some time hesitated to do so. I hesitated because I felt the difficulty of treating a subject of this importance, and of this extent, with anything like justice in the compass of an ordinary lecture. But, on the other hand, I am so anxious to avail myself of every opportunity of bringing it with passable fairness before all who are interested in the well-being and efficiency of the soldier—I am so conscious that the members of this Institution are of all men the most capable of appreciating and of testing the merits of any scheme claiming to further this object—I am so impressed with the importance of the subject itself—I have had such ample evidence of its value, and, as I believe, I can produce such convincing proofs of the power of the system of bodily training which I advocate to accomplish the object desired—that I hastily overcame my first scruples, and have endeavoured to prepare a short paper, touching, as far as time would admit, on its chief features, feeling sure you will extend to me your indulgence, in consideration of the difficulties I must encounter in any attempt to treat a subject embracing so many details in so brief a space of time.

But before doing so, before bringing to your notice any proofs of the value of the system, before attempting to show the advantages which one form of exercise possesses over another, I would ask your attention to some remarks, perhaps not very easy to follow, on account of the brevity with which it has been necessary to treat them, on the nature of exercise; I mean exercise in its abstract sense, whether taken for amusement, recreation, or with the avowed purpose of obtaining from it, what it is found by experience to give—strength; in short, I will endeavour to show what exercise is, what it does, and how it does it.

Exercise may be briefly defined as muscular movement. Muscular, because all movements of the body are executed by the muscles. It is by the action of the muscles, separately or in concert, that our every move-

ment, great or small, from the lifting of a finger to the most powerful effort of which the human body is capable, is performed; the power of executing such movements being always in proportion to the contractility, or, in other words, to the strength, of the muscles employed, evidenced externally by their development.

Now, it is an unerring natural law, that wherever the blood, which is the source of nourishment to the entire body, is circulated in the most abundant quantity, there will be the greatest development; and, by an equally unerring law, the quantity of blood circulating through each part is chiefly regulated by its exercise. Will you allow me to repeat this passage, it is so very important? "Wherever the blood, which is the source of nourishment to the entire body, is circulated in the most abundant quantity, there will be the greatest development—and the quantity of blood circulating through each part is chiefly regulated by its exercise." In other words, the development of the body, or of any part of the body, will be in relation to its activity, because the circulation of the blood in that part is in relation to its activity. The results of this law are familiar to us all in the fact that every one of the four hundred voluntary muscles of the human body will develope, will increase in size, strength, and dexterity, exactly in proportion as it is called into action. Whatever muscles of the body are called most frequently into action, whatever muscles of the body are most frequently exercised, will be found to be proportionately the largest, the strongest, and the most dexterous. For the present purpose we will view this as the first object of exercise—to increase the power and dexterity of the voluntary muscles of the body.

But in addition to these muscles which perform the various movements which we desire, and which are placed for the most part on the external surface of the body, forming the walls of the upper and lower cavities of the trunk, and constituting the principal bulk of the limbs, there is another class, small in number, and for the most part contained within the cavities of the body, over which we can exercise little or no control—muscles chiefly employed in the processes of digestion, circulation, and respiration, and called involuntary muscles. As I have said, and as their name implies, over these we can exercise no control, but they are equally susceptible with the voluntary muscles of improvement by exercise. For, although the movements constituting the exercise are performed by the voluntary muscles, the impetus given to the circulation in these parts is shared in a greater or a less degree by the rest of the body. We are all familiar with the increased warmth and pleasurable energy felt during and for some time after exercise, where it has not been too violent or too long protracted; this is caused by the greater rapidity with which the blood is circulating throughout the body; and the involuntary muscles are also stimulated by it to activity, evidenced by the increased and energetic beating of the heart and quickened and more powerful respiration. So that, although the exercise be executed by the action of the voluntary muscles alone, yet the health and vigour and capacity of every organ of the entire body will be with them proportionately increased. And thus we may view as accomplished the second object of exercise—to strengthen and develope the all-important organs on which not health only, but life itself, depends.

But there is another advantage of the greatest importance accomplished by exercise—accomplished by the energetic action of the voluntary muscles—I mean the effect of exercise on the condition of the blood itself, from which, as I have said, the whole body receives its nourishment. In every breath we breathe, whether asleep or awake, in sickness or in health, a double process is performed within our lungs—a double process acting directly on the blood at the moment of its passage through them. First, the blood which, as I may say, has made the circuit of the body, having parted with its nourishing and revivifying properties during the first half of its journey, and returned loaded with the waste and effete particles which it has received on its backward course, meets with the air inspired, and to this air it imparts, to this air it resigns, by this air it is relieved of, the load of waste material, principally in the form of carbonic acid gas, a gas which is itself a deadly poison, and the accumulation of which in the blood is productive of innumerable evils. This is one part of the process which takes place in the lungs during the act of breathing, namely, the setting free from the blood of the impurities with which it is charged; the second part is the absorption from the newly inspired air of a relative quantity of oxygen, which is as valuable, as necessary to life, as the carbonic acid is inimical to it. Now, as every one is aware, the direct and immediate effect of exercise is to quicken respiration, and not only to quicken it, that is, to make the separate inspirations and expirations follow each other with greater rapidity, but to make each separate breath of air larger in quantity. What is the direct effect of this accelerated speed and increased volume of the air respired? The blood is more perfectly aërated, is more abundantly supplied with oxygen, more freely and effectually relieved of its carbonic acid. And more than this. The lungs are but one of several organs whose office is to relieve the blood of all matters which might prove injurious to the health of the body, and these organs are all equally stimulated to increased activity by exercise, and receive from it equal permanent benefit.

At what point have we now arrived? First, we have seen that the development of the muscular system depends upon exercise. Secondly, that the health and strength of the vital organs also depend upon exercise. Thirdly, that the purity and nutritive condition of the blood, from which the whole body is nourished, also depend upon exercise; and that these various processes all tend to produce the same results, namely, the health and strength of the body.

I have said that development is in relation to activity, and that strength is, *cæteris paribus,* in relation to development, and this is the key to all physical improvement. We have but to ascertain what part of the body is the weakest, and by giving it suitable exercise we can strengthen it. We have but to ascertain what part of the body has received the smallest share of employment, and consequently the least nourishment, and consequently again has attained the smallest development, and instant means can be taken to remedy the evil, to increase its size and capacity, to improve its conformation, and place it on an equality with the rest of the body.

These being the sure results of exercise, it becomes a matter of the gravest importance to consider what forms of exercise are in themselves the most valuable. It is here, therefore, that I would now desire to direct

your attention to the distinction between purely recreative exercise and systematised exercise or gymnastics; I mean, between exercise which is taken for the amusement, the interest, the pleasure, which some game, sport, or pastime affords, and that which is taken for the sole purpose of the training and strength which it gives. Now, although recreative exercises do undoubtedly give strength also—health and strength to both mind and body—and earnestly as I would recommend that they should have every facility provided for their practice, and should be encouraged by every available means and every suggestive expedient—still it must never be forgotten that not one of these has for its object to develope the body, to give to it, or to any part of it, health and strength. So far from the weakest parts of the body receiving special culture on account of their weakness in recreative exercises, it is just the contrary; the parts of the body chosen to execute the movements of the game are those which can do them best, those in fact which are already the strongest and most dexterous. Not one of them is sufficient to accomplish the perfect development of the body, to bring it to that point of strength, dexterity, and power of endurance to which it is capable of attaining; and to expect this from them, is to expect what they were never designed to give. To accomplish this requires exercise of another kind—exercise prepared upon a clear comprehension of what is required, and how the thing required is to be obtained. It must be exercise for its own sake, exercise for the distinct purpose of the culture of the body. And this is the place claimed by gymnastics, these are the objects which they can accomplish. While I claim for their practice, if the gymnasium be in the hands of a competent superintendent and his instructors be properly qualified men, as high and as intelligent an interest, as great amusement and pleasure, as in any purely recreative exercise, the attainment of bodily health and strength is the one thing aimed at. I claim for the system that I advocate, that, no matter what may be the state of a man's health at the time he begins his work, if he be as weak as a child in the nurse's arms, or the most powerful athlete in his regiment, the exercises of the gymnasium can be regulated to his power—can enable the weak to begin without danger, without disappointment, without any risk of failure that could wound his *amour propre*, or lower him in the eyes of his comrades, but, on the contrary, will afford him a fair starting-point from which he can daily, hourly, lesson by lesson, add to his little store of strength, until he stands abreast with his fellows. And to the powerful man it affords the opportunity of showing his strength, of sustaining his strength, of preserving it intact, serviceable and disposable at any moment for the exigencies of his profession.

I arrive now at the important question, that question to which all the foregoing is but introductory, Does this apply to the position of the soldier? To put it more directly, Do the duties of the soldier yield that abundant physical employment which ensures the full development of his bodily powers? and do the exigencies of his profession require or render valuable the possession of great physical resources?

It will be conceded that the men who fill the ranks of our army are drawn from almost every species of trade, occupation, and calling, and embrace almost every grade of physical power;—massive, powerful men

from the farm, the quarry, the forge, the warehouse and the wharf, and slight, half-formed, half-fed youths from the factory, the shop counter, the desk, and from the innumerable petty trades in which men find employment in closely populated districts. I believe it may be roundly stated that every occupation followed in this country is represented in the army; and, Gentlemen, if what I have stated regarding exercise and its results be correct—and it is founded on the clear and accepted laws which govern our growth and development—to state that every form of occupation in this country is represented in the army, is virtually to state that every form of growth and development is represented there also. (I mean of course within those limitations observed in the enlistment of recruits and subsequent medical examinations). Now, most of the occupations in which artisans and labourers are engaged give powerful and active employment to certain parts of the body, the other parts receiving comparatively little; and the inevitable result of this unequal employment is unequal development, because power is in relation to activity. The parts that have been actively employed will be shapely and strong; the inactive, neglected parts will be weak and stunted. And this will be evident to every eye that knows what proportions to look for; the nature of the employment leaves its mark upon the man for good or for evil—a sign, a seal in witness of his strength and beauty, or a brand denoting his weakness and deformity—fashions him, moulds him for shapelessness or distortion so unerringly, that to the experienced eye the nature of the craft or calling is instantly revealed; or, the occupation being known, you may tell before looking at the man the condition and the direction of his development.

This is the material out of which the soldier is to be formed; rather, let me say, these are the men to whom is to be taught the profession of arms, than which there is none more noble; there can be none so noble, since in the keeping of the soldier, confided to his care, entrusted to his guardianship, are the prosperity, the safety, the honour of the country.

In men drawn from so wide a field will be found every gradation of physical strength, the strongest and the weakest. To take the two extremes for illustration, and to begin with the man of large stature and powerful frame; how has he acquired his powerful frame? Chiefly by energetic and powerful exercise. Other things may have contributed, indeed must have contributed, such as abundant diet, and probably fresh air; but neither of these, nor both of these, nor all the other agents of health put together, will give muscular power without muscular employment. Now remove such a man suddenly from his employment, take him to the depôt to be straightened and taught to march with his head upright, his arms close in by his sides, and the trunk of his body held erect and motionless as a pillar, and what are you doing? That which is suitable and necessary to enable the man to take his place in the ranks as a soldier, but nothing whatever to sustain, far less augment, his bodily energies. The constrained position, the restricted and closely localized movements of parade and drill, all deny to the trunk of the body and the upper limbs any exercise whatever, any share whatever of that which has given them the strength which they possess, for a continuation of which they are pining, without which they must dwindle to the loss of their shape and size

and power, and the still more important loss to other parts of the body, depending for their health and activity upon the health and activity of these.

But there is another condition of large stature and rapid growth which I would desire to instance; I mean the man of large frame with little strength, the results usually of a strong and unsubduable germ of growth in the individual, which, with adequate diet and suitable and abundant exercise, produces those splendid specimens of men whom we are fain to view as the type of our race, but who, with an inadequate or irregular supply of these agents during the period of their upward growth, attain the bulk of frame, but miss the soundness of constitution and the physical energies which should accompany it. There are many of these men in the army—there must ever be many of these men in the army. We have only to think for a moment of the insufficiency of diet alone, insufficiency in quantity and quality, at a time when abundance was a necessity to either present or prospective health or strength, to know that we have got the *shell* of the man only. Sound, strong, or lasting, he cannot be, because in him we have distributed over a large surface that which is only adequate for a small one. Is it possible yet to restore him to the place he was designed to occupy, designed by the incontrovertible evidence of his stature, attained in spite of his deprivations? Is it possible to give him that soundness of constitution, energy of muscle, elasticity of action, and symmetry of form which were his by birthright? Not possible—not possible to give, after growth is completed, that which should have regulated growth itself, beginning with its beginning, adding to, proportioning, consolidating, and sustaining every cell of every fibre or tissue, as it was added to the frame: but still possible, still feasible, still a certainty, yet to recover a valuable portion of the health and strength, activity and energy of which he has been deprived; still possible to double his material well-being as a man, to double his serviceability as a soldier. At once, the first day he is recognised in the depôt as an embryo soldier, take him to the gymnasium, prepared, fitted, built for his reception and use; place him under the care of instructors, taught to administer exercise on a clearly defined and comprehensive system, a system calculated to meet the requirements of every learner, weak or strong, to meet the requirements of the whole frame of every learner, and to give to the whole frame suitable and uniform and adequate employment. Do this, and you will create within him a new growth, a new life; a growth for the rectification of all that is wrong, and strengthening of all that is weak; a life within each separate cell, straining for the recovery of that which has been neglected since his birth.

Let us take another instance. The youth who has everything to gain—slight and slim, under-sized and under-fed, who can scarcely be reckoned the raw material out of which a soldier is to be made, but who from his youth, and from that strong germ of physical power which I have learned to look upon as inherent in the frame of every Englishman, is awaiting but the stimulating, quickening, life-giving properties of judiciously regulated exercise to swell and expand into healthy, vigorous existence. What does such a youth gain in drill and parade for the development of his latent resources? He is not twenty yet; capable of receiving vast additions to his physical powers. This is the case with Oxford men, who from their childhood have been living in that state of mental and physical

employment most favourable and most directly conducive to timely development. They seldom attain to their full bodily powers before their twenty-third year. But the youth of the nature I am instancing will be found to be greatly in arrears at all points. What is there in his professional duties to supply the want? So little, so very little, in comparison with his great requirements and almost unlimited capacity for improvement; and that little so partially and so unequally administered, that even its value is reduced. For observe, he cannot attend a parade, walk to a rifle-range, cross a barrack-yard, or ascend a barrack-square, without giving employment to the muscles of his lower limbs, although such employment be altogether inadequate to produce their full development; but it is abundant in comparison to what the upper limbs and trunk receive. These must languish, these must remain relatively feeble, because they are kept without employment, and power is in relation to activity.

It is this inadequacy, this partiality of exercise employed without reference to this law, which render gymnastics or systematised exercise so valuable, for by it only can employment, suitable in nature, degree, and duration, for every part of the body, be provided—and, while the comprehension of this law teaches us how to look for partial developments, and defective and imperfect growth, it has but to be ascertained what these local wants are, what parts of the body are relatively weaker than the remainder, and such employment can be furnished as will raise any such part to the rank of the rest of the body in strength and in serviceability. And, where the entire body is below the point of power to which it should have attained, suitable employment can be furnished for every part, for the whole collectively—employment that can be increased and intensified with the advancing capacity of the learner. And it must never be forgotten that in developing a limb to its full power and perfect conformation we do that, and, except indirectly, we do nothing more; whereas a glance at the trunk of the body will show that in developing the parts of which it is composed, I might almost say constructed, so numerous are its parts, and so complex is their arrangement, we do that and a great deal more. We not only develope to their normal shape, size, and capacity the important muscles of the trunk, but at the same time, and by the same process, we bring to its perfect shape and size the framework which encases and protects those vital organs, whose health and functional power we have seen to be all important. The health of these organs, and their power of performing their functions with due completeness, are essentially dependent upon their perfect freedom; and this freedom they cannot have, if confined and restricted by the narrowness, or other deviation from the natural shape and size, of this enclosing framework; they cannot attain to their full size and power if thus fettered, and no activity on their part can do other than aggravate the evil of their confinement. In thus providing, therefore, for their freedom in functional activity by the expansion of the chamber in which they lie, we directly aid in their development, directly increase their power.

But can I prove, can I adduce any evidence, that the system of bodily training which I advocate would meet the end desired, would adjust and regulate and place under his control the entire available resources of the strong, would sustain and add to his strength and increase his professional

serviceability—that it would take up the comparatively unformed, undeveloped, and altogether negative, frame of the young recruit, and cultivate him into an energetic, active, and strong man? I have no hesitation whatever in saying that it will do both of these, and I believe I can give sufficient evidence that I do not over-estimate its power.

Many years ago I instituted in my gymnasium at Oxford a series of measurements, by which I could ascertain the state of the development of all pupils at the commencement of their instruction, and, these measurements being repeated at given intervals, I could know the rate of their advancement. The revelations made by this system of periodic measurements have been such, as to sustain me in devoting my entire energies to the completion and extension of my system of exercise. I find that to all, child or adult, weak or strong, it gives an impulse, a momentum to the development of his resources, which nothing else can give;—and which nothing can take away, because it is not a thing acquired, a mere mental or physical acquisition; it is the man altered, the man improved, the man brought nearer to the state he was designed to hold by the nature of his organization.*

But the question will naturally present itself, Would the same results be obtained from a similar system of bodily exercise by the men who fill the ranks of our Army as by the youths passing through our Universities? I think the statements which I have now to make, will satisfactorily answer this question.

The first detachment of non-commissioned officers, twelve in number, sent to me to qualify as instructors, were selected from all branches of the service. They ranged between nineteen and twenty-nine years of age—between five feet five inches and six feet in height—between nine stone two pounds and twelve stone six pounds in weight—and had seen from two to twelve years of service. I confess I felt greatly discomfited at the appearance of this detachment, so different in every physical attribute; I perceived the difficulty, the very great difficulty, of working them in the same squad at the same exercises, and the unfitness of some of them for a duty so special as the introduction of a new system of bodily training into the army—a system in which I have found it necessary to lay down as an absolute rule, that every exercise in every lesson shall be executed in its perfect form by the instructor, previous to the attempt of the learner; knowing from experience how important is example in the acquisition of all physical movements, and how widely the exercises might miss of their object if unworthily represented by an inferior instructor. But I also saw, that the detachment presented perhaps as fair a sample of the Army as it was possible to obtain in the same number of men, and that if I closely observed the results of the system upon these men, the weak and the strong, the short and the tall, the robust and the delicate, I should be furnished with a fair idea of what would be the results of the system upon the Army at large.

I therefore received the detachment just as it stood, and, following my method of periodic measurements, I carefully ascertained and registered

* A few of these results I have made known in a paper read by me at the meeting of the British Association at Oxford two years ago, and since published in "Macmillan's Magazine," Nov. 1860.—A. M.

the developments of each at the commencement of his course of instruction, and at certain intervals throughout its progress. A tabular statement* of these measurements will appear, I believe, in the forthcoming blue book, as they were furnished by me to Dr. Logan, the Inspector-General of Hospitals, with whom I have had the pleasure to be associated on the Committee appointed to consider the question of the introduction of these exercises into the Army; but I may here mention that the effects were beyond my most sanguine hopes, and equal to any precedent among the youths in those higher positions of life among whom my observations had been hitherto chiefly made. The muscular additions to the arms and shoulders and the expansion of the chest were so great as to have absolutely a ludicrous and embarrassing result, for before the fourth month several of the men could not get into their uniforms, jackets and tunics, without assistance, and when they had got them on they could not get them to meet down the middle by a hand's breadth. In a month more they could not get into them at all, and new clothing had to be procured, pending the arrival of which the men had to go to and from the gymnasium in their great coats. One of these men had gained five inches in actual girth of chest.

Now, who shall tell the value of these five inches of chest—five inches of additional space for the heart and lungs to work in? There is no computing its value, no power of computing it at all; and, before such an addition as this could be made to this part of the body, the whole frame must have received a proportionate gain. For the exercises of the system are addressed to the whole body, and to the whole body equally, and before this addition could be made to the chest every spot and point of the frame that you could touch with the tip of your finger must be improved also; every organ within the body must be proportionately strengthened.

But I tried another method of recording the results of the exercises. I had these men photographed naked to the waist shortly after the beginning of the course and again at its close; and the change in all, even in these small portraits, is very distinct, and most notably so in the youngest, a youth of nineteen, and, as I had anticipated in him, not merely in the acquisition of muscle, but in a readjustment and expansion of the osseous framework upon which the muscles are distributed.

But there was one change—the greatest of all, and to which all other changes are but means to an end, are but evidences more or less distinct that this end has been accomplished—a change which I could not record, which can never be recorded, but which was to me, and to all who had ever seen the men, most impressively evident—and that was the change in bodily activity, dexterity, presence of mind, and endurance of fatigue; a change, gentlemen, a hundredfold more impressive than anything the tape measure or the weighing chair can ever reveal.

The results upon the second detachment of instructors whom I am now qualifying are equally satisfactory, but more uniform, the men having been more specially selected.

Up to this point, gentlemen, I have spoken but of the beneficial results of exercise as affecting the man, without special reference to his profes-

* See table in Appendix.—Ed.

sional duties as a soldier; and I have done so purposely, because you will in a moment see that the power of the man and the serviceability of the soldier are inseparable conditions. Our embodied idea of energy, activity, and strength is the soldier, these qualities trained to, made subservient to, the exigencies of his profession ; and these qualities are the inevitable results, the incontrovertible results, of that system of bodily training which I advocate, because the system itself is based upon, and all its directions are in accordance with, the natural laws which govern the growth and development of the human body. Endow a man with these qualities, therefore, and you endow him with the power of overcoming all difficulties against which such qualities can be brought to bear, against all difficulties requiring strength, activity, energy, dexterity, presence of mind, tenacity, and endurance. You cannot limit a high qualification to a single use any more than you can limit the purpose to which a good coin may be applied; it will fetch its value anywhere and in anything. And so will strong muscles and sound lungs—in garrison, in camp, or on campaign, on the march, in the field, in the transport, in the hospital, on any service, in any climate.

But, although we cannot limit the use of a qualification, we can very readily give to it a special direction by special care, and make it more distinctly valuable for special purposes. And this is emphatically the case with the application of the powers acquired by gymnastic training to the duties of the professional life of the soldier. Indeed, as will be seen by the published book of the system, this is the ultimate aim and object of every exercise in it, and this is clearly inculcated and steadily kept before the learner throughout his instruction. And the last course in the system consists exclusively of the practical application to a professional use of all that has gone before, teaching the soldier how to overcome material obstacles of every form, position, and character, surmountable by walk or run or leap or vault or climb, with implements and with arms, singly and self-dependent, or with comrades rendering and receiving mutual assistance.

Therefore the question which I have advanced, "Do the exigencies of a soldier's life require or render valuable the possession of great physical resources?" I will not further answer, because the answer is apparent on the face of the question itself, and the question was only put to emphasize the importance of the subject to which it refers. I feel it would be unbecoming in me further to enlarge upon this subject before professional men, acquainted by life experience with all the forms in which the exigencies of the soldier's profession make daily, hourly claim upon his physical resources, and who know that health and strength are the essence of the soldier's power.

Nor need I repeat here, because they must be familiar to you all, the startling statistics which show the small per-centage of men who fall by the weapons of the enemy, in comparison to those who succumb to the demands made upon their bodily energies. For the one enemy in his own form which the soldier has to encounter, there are a hundred lurking around him unseen, in the form of sufferings which originate in the manifold trials of his professional life. He cannot stand the heat, or he cannot stand the cold; he cannot stand the

terrible exertion and excitement of the struggle, or he cannot stand the monotony of the camp and wearisomeness of the march; he cannot subsist on the scanty and ill-prepared rations; he cannot bear up against the broken and insufficient rest. Against his single human foe we put into his hands the most perfect weapon invented—I might almost say inventable—by man; against the other foes that lurk in his path, awaiting him at every turn, there is but one protection—to strengthen the soldier himself.

In conclusion, I would merely remark, that while this is applicable to the soldiers of every country, how much more so—with how much greater force—does it apply to our own, who have to pass from station to station over the whole world, who have to endure the extremes of every climate, from the almost arctic cold of Canada to the tropical heat of Africa and the Indies? If physical energy and constitutional strength be the essence of power in the soldiers of any other nation, they must be so with strange distinctness in those of ours, who have to exercise their profession over almost every country on the face of the globe, and to endure the hardships, the fatigues, the discomforts of them all.

In this paper I have spoken only of the physical advantages which the soldier would derive from a systematic bodily training, but its value in a moral point of view would be almost as great, as evident, and would be assured by the natural action of laws as plain as those which regulate his material improvement. I do not allude merely to the filling up healthfully, pleasurably, and profitably of his spare time—I do not allude merely to the evidence which it would set before him of how health and strength are gained, and how they are lost, and of the immeasurable advantages which the possessor of these qualities has, in every situation of life, over the man who has them not—I allude to the well-known physiological fact, that active bodily exercise has the direct effect of checking that desire for stimulants and excitements and sensuous indulgences, which sap and undermine the constitution, and waste and wear out the soldier's frame, and which arises, not so much from any physical want, or for the natural gratification of any legitimate physical desire, as from a nervous irritability and craving, that become the stronger the more they are indulged, and the strength and force of which are usually in an inverse ratio to the bodily strength and power of the individual—in an inverse ratio to his ability to indulge in them with impunity.

APPENDIX.

The Gymnasium, Oxford,
April 26th, 1861.

Dear Dr. Logan,—You expressed so much interest in the report which I sent you some time ago on the progress made by the men whom I am qualifying as gymnastic instructors, that I am induced to send you a second, showing the ultimate results of their course of instruction, for they return to Aldershott to-morrow.

Had I, in this first attempt to introduce gymnastic exercises into the Army, been desirous merely of producing a number of athletes, I should have requested the exchange of some of the men; but I considered that I

should be more correctly interpreting the wishes of his Royal Highness in accepting whatever men were sent to me, and thus testing the value of the system by its effects upon men of widely different degrees of physical power, stature, age, and constitution. For this reason also I have not restricted my tests to the ordinary course of measurements instituted in my school; in the first week of their instruction I had a photograph of each man taken in a position to show the state of the muscular development of the upper limbs and the general conformation of the chest; and in this, their last week, I have had these photographs re-taken, and I think you will consider the results which they manifest of sufficient importance to warrant my thus drawing your attention to them. Here, in Oxford, where I yearly receive large numbers of youths from our public schools, I have been enabled to make extended observations on the results of systematized exercise on their frames and constitutions; but I confess I was not prepared to find that men in another rank of life, whose early habits and occupations must have been essentially different, were equally capable of physical improvement.

I have arranged the names and portraits according to age, and you will see that from the youngest to the oldest, the first only in his 19th year, and the last in his 29th, and counting twelve years' service, all have made great and general improvement; those who required it the most having had the greatest gain, for evidence of which I would refer you to No. 9, originally a delicate man, now a comparatively strong one. But it is to the first on the list that I would most particularly desire to direct your attention; for, as you will see, the physical condition of this young man has been in a few months so materially changed, that, when the features are concealed, one would scarcely imagine that the photographs represented the body of the same individual. I need not say that the alteration must be great to show at all in these small portraits. Moreover, his is the temperament and the nature of body—thin, hard, and spare—that is least susceptible of change and material increase.

If, therefore, I am correct in viewing these men as fairly representing those who fill the ranks of our army, the same good which has been obtained by these may be obtained by all; and, if the case of the youngest of the detachment represents the condition of the recruit and young soldier, I think I am right in assuming that were this system of bodily training administered to them at the outset of their military service—while with some the upward growth is still going on and with all the lateral development is in full force—not only would their physical powers be doubled for every use to which they could be applied, whether for the overcoming of obstacles by strength and activity, or for the endurance of protracted exertion, fatigue, or privation, but, what you will perhaps agree with me in viewing as a greater good, this vast and permanent expansion of the chest will powerfully aid in resisting or in giving exemption from those forms of disease which specially attend the duties and habits of the soldier.

I remain, dear Dr. Logan,
Yours very faithfully,
ARCHIBALD MACLAREN.

T. G. Logan, Esq., M.D.,
Inspector-General of Hospitals.

TABULAR STATEMENT OF MEASUREMENTS OF 1st DETACHMENT OF NON-COMMISSIONED OFFICERS SELECTED TO BE QUALIFIED AS MILITARY GYMNASTIC INSTRUCTORS.

Measurements.									Increase.				
No.	Name.	Date.	Age.	Height.	Weight.	Fore Arm.	Upper Arm.	Girth of Chest.	Height.	Weight.	Fore Arm.	Upper Arm.	Girth of Chest.
				ft. in.	st. lbs.	ins.	ins.	ins.	ins.	lbs.	ins.	ins.	ins.
1	Sergeant Smith,	Sept. 11.	19	5 8½	9 2	9½	10	33					
	55th Foot .	April 30.		5 8⅞	10 1	10½	11¾	37½	⅜	13	1	1¾	4½
2	" Jackson,	Sept. 11.	21	5 9	10 5	10	11	34⅝					
	49th Foot .	April 30.		5 9¼	11 1	11	12¼	38½	¼	10	1	1½	3⅞
3	" Flannigan,	Sept. 11.	23	5 5	9 7	10½	12	34					
	41st Foot .	April 30.		5 5¾	10 2	11½	13¼	37½	¾	9	1	1¼	3½
4	" Reilly,	Sept. 11.	23	5 7½	9 13	10¼	12	37					
	18th Hussars	April 30.		5 7⅞	10 8	11½	13	38½	⅜	9	1¼	1	1½
5	" Tarbotton,	Sept. 11.	23	5 8¼	9 10	10	11	36					
	5th Lancers	April 30.		5 8½	10 6	10½	12	37	¼	10	½	1	1
6	" Steel,	Sept. 11.	23	5 9⅛	11 3	11	12	36½					
	32nd Foot .	April 30.		5 9¼	11 12	11½	13	38½	⅛	9	½	1	2
7	" Bartlett,	Sept. 11.	23	5 9	10 6	10¾	12	36					
	R. A. . .	April 30.		5 9½	10 11	11	13	38½	½	5	¼	1	2½
8	" Kearney,	Sept. 11.	24	5 8¾	10 8	10¾	12¾	35					
	10th Foot .	April 30.		5 9¼	11 6	11¾	14	40	½	12	1	1¼	5
9	Corporal Sheppard,	Sept. 11.	26	5 6¼	9 5	10	11½	33					
	R. E. . .	April 30.		5 6⅞	9 11½	10¼	12¾	36	⅝	6½	¼	1¼	3
10	Sergeant Beer,	Sept. 11.	26¾	5 11⅜	12 6	11½	13	41					
	R. A. . .	April 30.		5 11¾	13 1	11½	14	42	⅜	9	—	1	1
11	" Cox,	Sept. 11.	28	5 7⅞	10 10	10½	12½	37					
	16th Lancers	April 30.		5 8¼	11 9	11¾	13¾	40	⅜	13	1¼	1¼	3
12	" Rafferty,	Sept. 11.	28	5 10⅞	10 9	10⅛	13	37					
	45th Foot .	April 30.		5 11	11 11	11⅝	14	40	⅛	16	1½	1	3

Archibald MacLaren,
The Gymnasium, Oxford.

Evening Meeting.

Monday, March 3rd, 1862.

Captain E. G. FISHBOURNE, R.N., C.B. in the Chair.

ON THE PROTECTION OF THE BOTTOMS OF IRON SHIPS FROM CONCUSSIONS AND FROM FOULING.

By John Grantham, Esq., C.E., &c. &c.

Mr. Grantham.—I think I need no better apology for appearing before you this evening, to explain the subject which I have to introduce to your notice, than will be afforded by reading a few lines from the report of the debates in the House of Commons on Friday last. They relate to this special subject, and show, I think, that on the public mind the question we have now to consider is the one which of all others is at present preventing the extension of the use of iron in the building of ships for the Navy. Lord Clarence Paget said: "The honourable Member for Birkenhead was probably better acquainted with the comparative merits of wood and iron than anybody else; but the service of mercantile vessels was a very different thing from the service of men-of-war. Our ships had to be sent to all parts of the world, and they remained abroad for three or four years. Every practical sailor knew that a vessel with a foul bottom would neither steam nor sail, and became utterly useless as a man-of-war. We had not yet got over that difficulty in iron vessels. That it would be eventually overcome he had no doubt; but as long as it existed it would be unwise for the Government suddenly to abandon the building of our smaller ships in wood. Our copper-bottomed vessels were good for two or three years without going into dock. That would not be the case with iron ships. He believed, indeed, that with iron ships we would require docks all over the world; and, upon the whole, he thought we could not do better than continue the construction of small wooden vessels."

Here the subject turned on the question of fouling.

Mr. W. Duff referred to two iron vessels which were on the South American station when he was there. There were no means of docking them on that station, and at the end of five years one of these vessels could hardly move at the rate of two knots an hour. She was one hundred and ten days on her voyage home, had to consume her own bulk-

heads for fuel, and was given up for lost; while the other ship was three months on her voyage. Until further experiments had been tried, he hoped the noble Lord would not build our vessels entirely of iron. For purely fighting purposes, iron, which would keep out shells, was no doubt desirable, and iron frigates ought to take the place of wooden line-of-battle ships; but he did not think that the day had arrived for replacing wooden by iron ships on foreign stations.

Again the whole subject seemed to turn on the question of fouling.

Sir J. Elphinstone pointed out that, if iron vessels were sent to distant stations where there were no docks, they would in course of a little time become unserviceable.

A remark was made by Mr. Bentinck; but it had reference to another point, not to the question of fouling—viz., the strength of the bottom of iron ships.

Mr. Bentinck said: "As to iron ships being stronger than wooden ships, that was true in some cases; but in others it was not so. If an iron vessel went ashore upon a sandbank, she would hang on there a long time; but if she went upon a stony or rocky shore, she would go to pieces like brown paper."

That I think is an extreme view of the case; but it evidently had reference to the facility with which iron ships are pierced by hard bodies.

Mr. Laird, speaking on the subject of docks, said "he was rather surprised, looking at the increased size of the ships now building, and the very inadequate number of graving docks, that a larger sum was not taken to remedy this state of things. There was scarcely any graving dock that could take these vessels in. At Portsmouth there was only one, and he wished to know what steps were to be taken to provide the requisite accommodation."

Mr. Corrie speaks on the same subject, especially with reference to the necessity of frequently docking iron ships.

I had the honour last year of bringing under the notice of this Institution the subject contained in the present paper. It was then however only mentioned incidentally in the course of the discussions which followed Captain Halsted's paper on Iron Ships for the Navy. It is felt that an evening devoted to this question will not be time lost, and that the paper now to be read, and the discussions that may follow, may tend to throw some light upon and clear up some of the difficulties in the way of the removal of the only remaining objection to the employment of iron ships for the Navy. All subjects of this kind must be relative; no one is sanguine enough to suppose that a ship can be rendered invulnerable to rocks, or kept under all circumstances free from the adhesion of weeds and shells; we can only attain to approximate safety, and all modern improvements are only so many steps in attaining to greater security, higher speeds, and a better adaptation generally for the requirements of ships. These relative qualities can only be measured by what has gone before, therefore the best we can claim is to have done something *better*.

Now beyond all question iron possesses qualities that render it better adapted than wood for shipbuilding, and yet we, its most sanguine advocates, have never denied that certain defects have to be removed before superiority can be claimed for it in all its features.

In my own work on Iron Ships, written about twenty years ago, and of which a second edition appeared in 1858, the following remarks occur:—

"There is one source of risk to which iron ships are more liable than timber-built ships; I allude to the effect of a blow from a hard and pointed substance, such as the fluke of an anchor or a sharp rock. These have been found to penetrate the iron plates more freely than through the planks of a timber ship, supported as they are by the ribs, which form an almost solid bed under them." Again, "The fact that iron vessels become coated in tropical climates with shells and weeds, has operated considerably against them. . . . . That the objection exists cannot be denied, and it constitutes at present the most annoying circumstance connected with iron ships."

These quotations show that these drawbacks to iron ships are not now, as some suppose, discovered for the first time: we have long known them, and have never concealed them; but, in spite of them, iron ships are fast taking the place of wooden ones.

In the first case, to meet the disadvantage of having the plates pierced, we say, multiply the bulkheads as much as possible, and make them strong enough; and we also recommend those who navigate iron ships not to go upon rocks!

In the second, we say, apply such compositions as experience shows will keep longest clean; and when your ship goes to a tropical climate, get home as quick as you can, and put her in dock and clean her; but we are obliged to admit that if iron ships are to become universal they will get on rocks, and they must also be detained in climates where they will become foul.

It will be readily supposed that those practical men who have long been engaged in iron-ship building have given these questions their anxious attention; we have long been aware that copper sheathing is the only permanent remedy known for resisting the tendency of a ship to foul; and in proposing a system by which this may be safely applied to an iron ship, a practical method of enabling them to resist concussions from hard substances has also suggested itself.

Many attempts have been made to attach copper direct to the plates by some principle of adhesion, and one of these will, I believe, be exhibited to you to-night. I tried many of these some years ago, but abandoned them all; I then suggested the plan now before you. One man actually sheathed an iron ship formerly belonging to our Government with planks, and secured them by means of an immense number of bolts put through the plates, over this he placed copper, and the vessel had made two voyages into the Pacific when I last heard of her; but as the system of bolting was in itself bad, I cannot suppose that it could have any favourable result.

Another man, however—Mr. Jordan of Liverpool—made a much more successful attempt; and as it bears on our present question in many important respects, I shall again refer to it; but before doing so I will repeat some well-known reasons why the various compositions now in use do not meet the requirements of the case, nor act as copper does in preserving the ship from fouling.

It is known that the effect produced on shell-fish and weeds by the

copper is not purely a chemical question, but must rather be called mechanical. The oxidation of the copper, by constantly reducing its outer surface, prevents substances from adhering permanently to it. This has been shown when attempts were made to arrest the oxidation by a galvanic action being given to it; but the ship then became foul; shell-fish and weeds were not thrown off, and they had time to grow, as on iron ships.

I avoid specifying or giving more than a general opinion on the various compositions that are sold as remedies for this great evil; the fullest opportunities have now for some years been given them, and let the experience thus gained speak for itself. Upwards of twenty years ago, when the evil of fouling began to be sensibly felt, iron-ship builders used a composition that was considered efficacious, but which it was soon found was very partially successful. Some that I have seen since, and which have been claimed as new, were of a similar character. I may say generally that they cannot be substitutes for copper, because their action, if any, differs so much from it; none of them present a surface that is continually changing by the process of oxidation. Some of them present a smooth surface, and this naturally will keep clean longer than a rougher surface; but none of them, so far as I know, have been able to resist for any length of time the slow encroachments of that animal and vegetable life that arrests the career of the most powerful ships.

Like many others, I have contended that some simple thing would be found to meet the case, but time has produced nothing. For many years the subject has been under the anxious consideration of our best naturalists, chemists, and practical men, and, as far as I can judge, some of our first attempts at a remedy were as good, or nearly so, as any that have succeeded them. The cry still is, let us wait and something will be found; but I believe that nothing at present but copper gives any prospect of success, and the plan here presented to you admits of the ship being coppered while it is otherwise a protection to her against concussions.

Now it is remarkable that men who have long resisted any particular improvements or discoveries, no sooner become converts, than they fall into the opposite extreme and show an undue confidence in the new system. This has been remarkably illustrated in the various stages in the progress of iron-ship building, and this evil of fouling which the long consistent advocates of this material have felt to be so serious, is now said to be of minor importance. Why, Sir, the whole question of the fitness of the general introduction of iron ships into the Navy turns on this very question. Witness, amongst other things, the frequent remarks to this effect in the debates in the House of Commons. Not that remedies for this evil are not required for the merchant service, but they appear to be essential in the Navy. For a moment consider the case of the "Warrior," in herself a great success; in such a ship a high velocity is considered an essential qualification, and, whatever advantages iron may possess, they must all be given up if the adoption of it is to result in a diminution of speed. About £80,000 has been spent on her machinery; a large amount of space has been sacrificed to it, and the coals, of which about 150 tons per diem are required to drive her at full speed; and what will be the result? Send her into the Mediterranean, the gulf of Mexico, or to India, and, if left there, in a short time her speed will be seriously reduced,

and in six months her fourteen-knot speed will probably be ten, and in twelve months much less—probably seven would be her best speed. It is true when she gets into this state she may be cleaned, if you can get her into a graving dock, perhaps 1,000 miles from her station, or she may, if she can find it, be forced up into a fresh-water river, and there, after lying some time, be partially cleaned by the death of the weeds and animalculæ, whose natural element is salt water, and which cannot live in fresh. And then what follows? the ship is no sooner at sea again than the same process commences, only to be removed by resorting to a repetition of the same means. I suppose, however, that no graving docks out of Europe would receive our heavily-plated ships.

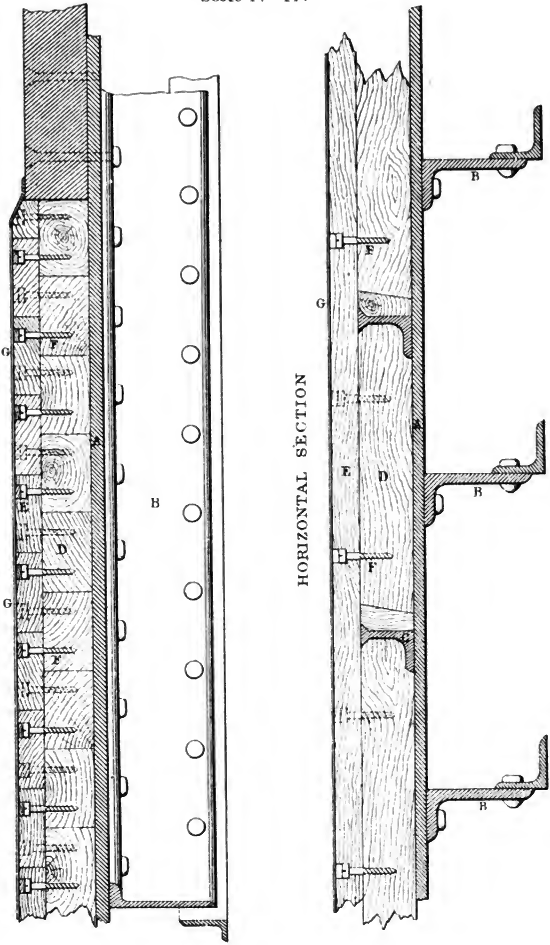
Now, that I have not overstated the case, I refer to the specimen of a moderate-sized barnacle, attached to the model of this arrangement, now in this Museum. This was one of many thousands taken from an iron ship, and is the growth probably of six or twelve months. When attached to the ship in its live state, a fish about as long as one's finger projects from every shell, causing a still more formidable obstruction.

But the case may be illustrated by well-known facts that occur in this climate, where shells seldom attach themselves, but which is due to weeds only, with a certain amount of roughness that rises in salt water upon ordinary paint. Every iron vessel for the first month after leaving the graving dock and having the plates cleaned, goes better than she does subsequently. This has been accurately tested by the new vessels belonging to the City of Dublin Steam Packet Company, which carry the mails from Holyhead to Kingstown. In the summer time, in about two months after leaving the graving dock, their speed uniformly falls off so as to increase the length of the passage ten to fifteen minutes, or equal to about half a mile to one mile an hour. After the first two or three months the retarding process in this country goes on slowly, but where shells attach themselves the contrary is the case. From these facts I am led to the conviction, which I have frequently heard expressed by others, viz., that in some cases, even in this country, it might be worth while to use copper for iron ships, should my plan prove successful. As the voyages of iron ships in the merchant service are extended, the evil is being increasingly felt. Large sums have been expended in Liverpool on the most splendid graving docks in the world, but, owing to the necessity of constantly docking the numerous large iron steamers now owned in that port, a much greater expenditure has become necessary to keep pace with the demand.

Having, I trust, shown some grounds for supposing that copper sheathing would be desirable if it could be applied, I now ask your attention to the drawings, and you will see that while the first object sought was a remedy for fouling, the same system supplies a very effectual protection against concussions, an advantage that must to some extent satisfy the requirements even of the strongest opponents to iron ships for the Navy. It will be seen that I commence by attaching frames to the outside of the vessel to run up to the light water-line, or to the armour-plates in large plate-clad ships. These frames are rolled like common angle iron, except that the outside edge is made of a wedge form, or flanged, as shown in the drawings; they are riveted to the ship in the usual manner. Between these is driven a timber planking, which becomes firmly wedged;

GRANTHAM'S SHEATHING FOR IRON SHIPS.

Scale 1in. - 1Ft.



A. *Section of Side Plates*
B. *Inside Frames*
C. *Outside Frames*
D. *Inner Planks*
E. *Outer Planks*
F. *Brass Screw Bolts*
G. *Copper Sheathing*

J.R.Jobbins.

and being set in with suitable compositions, and then caulked, forms a solid bed. This would be made from refuse timber cut from the wood used in the other parts of the ship. The whole being then dubbed even with the ribs, and again coated, another sheathing is attached by brass screws. I have made the inner one for large ships four inches thick, and the outer one two inches. The copper sheathing is then attached in the usual way.

Thus a firm substantial bed is prepared for the copper, all metallic contact is avoided, and great additional protection is given to the bottom of the vessel. I will endeavour now to anticipate and reply to the objections that may be used against this system.

1st. That it will be expensive;

2nd. That it will add to the weight of the vessel;

3rd. That it will injure the iron plates;

4th. That the timber work will become loose when the vessel strains.

There may be others which may be suggested during the discussions that I hope will follow the reading of this paper, and therefore I will deal with those I have named as briefly as possible. In all these discussions I take the "Warrior" as the vessel to which allusions and comparisons will be made, being most deservedly greatly in advance of all other ships in public opinion.

1st. As regards the expense. I estimate the timber, labour, screws, and coating at less than £4,000, if put on when the ship is building, on a ship valued at £350,000. The copper is not included. I claim against this, in making a ship of equal safety, a saving of 200 tons of iron, which, at £20 per ton, equals £4,000. But by far the largest set-off is to be found in the saving of steam-power, and for foreign service, I set this down in the "Warrior" at 500 horses, upon the average of a three years' cruise in warm climates, or 200 horses in the home service; or, what is more important still, that the vessel shall, if kept clean, at all times maintain her proper speed.

2nd. If the comparison is to be fairly carried out, the increase of weight will be very little. I claim a saving of 200 tons of iron, and the timber will weigh 280 tons, a difference of 80 tons in a vessel displacing 8,000 to 9,000 tons.

3rd. I deny that it will injure the plates; on the contrary, I assert that it will be a great protection to them, for being once well painted, the sheathing will effectually protect the paint, and while this remains unbroken, there is no fear of corrosion. There being no bolts to work loose, and no metallic contact, there is abundant evidence to show that the plates of iron ships, under such circumstances, will be entirely free from injury.

In some respects the iron-clad ships, as hitherto constructed, are much more unfavourably placed, a large portion of the woodwork which is used as a backing for the armour plates is below the water-line, having a 1,000 tons more or less of weight outside of it, suspended by bolts about two feet long running through the timber; and iron bolts that will loosen, and in time admit water, a defect that cannot take place with the sheathing now proposed—First, because there are no bolts; and secondly, instead of having a power tending to loosen it, there will be a pressure

of water equal to the weight of the ship, tending to make it cling to her sides and bottom, a power that no ordinary means could overcome.

I have heard it asserted that injury to the plates may go on unobserved beneath the woodwork. In the first place, the probability of such injury is very remote; at the worst the water can only penetrate to the plates and there remain quiet, and even there the coating will arrest its progress; but supposing further the plates to have no protection, what is to be apprehended? the water is at once deprived of its oxygen, an infinitely small amount of corrosion takes place, and then all further mischief ceases. If there were a constant stream or jet of water, damage might occur: but this would be impossible; it could at the worst only penetrate, and there remain at rest. Such alarms as these are only a repetition of what was experienced when iron ships first were used on salt water. It was then confidently asserted that they could not withstand the corrosion, but must soon perish. We now find that iron ships, well protected, are very durable.

But I have alluded to other evidence, viz. the vessels built by Mr. Jordan, as proving that iron in contact with wood sheathing and copper, though very unfavourably placed, has stood well for ten years.

Mr. Jordan's vessels were built with angle-iron frames and several plate ribbon-pieces, having planks secured by iron bolts outside all. These ships were coppered, and were in the East Indies since they were built in 1851; one of 400 tons was lost about two years ago, and one of 780 tons is still at work. As regards the plates and ribs, both vessels are said to have been in excellent condition, though exposed to very severe trials. The iron bolts which approach nearly to the copper have suffered as might be expected, and as would have been the case to a certain extent had there been no copper. The owner, a man of great experience, declares in a letter lately written to me that he would never build on any other system. I will quote a few of his remarks. Of the vessel that was lost, he said "that the bolts were to a considerable extent affected, although no other part of the iron framework was so. At the same time, it must be remembered that these bolts had been fully eight years in use, and were still strong enough to do their work. There was the utmost harmony between the wood and the iron; no straining was ever apparent, and consequently not the slightest deviation in the sheer or form of the vessel. With all the strength of iron, they had all the advantages of wooden ships—no fouling, for they were always coppered."

4th. The last objection which I have anticipated is, that the timber will work loose. Those who have raised this objection can surely not have reflected on what they were saying. Observe the drawing, and it will be seen that the means for securing the planks are much better than the ordinary means used for attaching them to a wooden ship; in this sheathing the planks are wedged most powerfully at very short intervals between frames, which themselves are riveted to plates that are perfectly unyielding in the direction in which the seams could open. Should any yielding take place, it can only arise from the plates cracking or the seams opening, and we know this to be last extremity of an iron ship. In fact, in a sound vessel such motion is impossible. But there is another action found in all ships—viz., the bending of the whole fabric when

working in a heavy sea. I have endeavoured to reduce the amount of this to figures, for in no other way could I estimate it, the movement on each joint being inappreciably small.

I do not know whether the lateral motion of the "Warrior" has been ascertained; but I have assumed it to be four inches in her entire length, in which case I make the average opening at the outer edge of each seam in the lengthways of the ship to be about the 17,000th part of an inch, or the 70th part of the thickness of an ordinary sheet of writing-paper, and the inner edge of the seam to be absolutely nothing but what may be allowed for in the positive direct stretching of the plate between each frame at every motion of the ship.

No one for a moment will doubt that the elasticity of the timber will much more than compensate for these small movements; and it may here be well to consider how this principle acts in every timber ship, and is essential to its safety—its very existence depends on the power in the timber and oakum of its seams to expand and contract; for, suppose they had not that property, but in that respect were like lead, which can be compressed, but will not expand again, having little or no elasticity, it is probable such a ship would founder in the first gale. May I not claim in this argument some benefit from a principle which is the sole dependence of every ship made of timber?

In the matter of repairs, it may be asked, Can the wood-work be easily replaced should part of it be damaged? To this I may reply that I believe it will be perfectly easy; the inner plank may be set fast by a double wedge at any part of the vessel without disturbing the rest.

I have now very briefly to ask your attention to this system in its action, as a buffer in case of collision with hard bodies. That it will so act is self-evident: externally it will endure whatever ordinary planks will, internally it will tend to spread the effect of the blow over a larger space; it will likewise interpose an elastic substance, which, in itself, will materially lessen the effect of the direct contact with a rock or other hard body. It may be a question worth considering whether the outer plank should not be stronger than I have shown it in the flat of the floor, and in those parts where contact with rocks is most to be apprehended.

In closing this paper I very reluctantly turn to some personal considerations. I will not venture to predict what judgment will here be passed on my remarks; I can only state what I know, viz., that this plan was described to gentlemen connected with the Admiralty about ten years ago. It was shown to Sir Baldwin Walker about three years ago, it has since been strongly recommended for adoption by the Plate Committee, and has been noticed by several scientific journals, in all cases favourably. It has also received the written and verbal approval of men whose opinions would always carry weight; but to this time no attempt has been made to test its qualities. The trial of it or any corresponding plan cannot be made in a day; it will take years before it can be fairly tested. Now, supposing a trial had been made in the year 1852, when I first made it known, and it had met with approval, I believe not a single wooden gun-boat would have been built for the Russian war, but that all would have been of iron; or, if Sir Baldwin Walker had recommended a trial three years ago, and it had succeeded, we should in all our new iron ships have

had a system on which dependence could be placed for the removal of the only drawbacks to the entire adoption of iron ships for the Navy.

The unfair question is put to me, Where are your examples, on what ships has it been tried? I ask, Who is likely to try it if the Government will not, for who has so large a stake in it? Can an individual try it? It has already cost me nearly 500*l.* in the mere introduction of it to notice. Can I be expected to do more? Its advantages cannot be fully appreciated in small vessels, though it is applicable to all; its principal recommendation is for large ones, and such vessels involve large sums; and when I request that a trial may be made, I ask for no great sacrifice or risk in making it. It could not destroy the usefulness of the ship, even though it might not have all the advantages which I propose. Is it, therefore, too much to hope that such a ship should be designed? and I have no hesitation in predicting that, while having all the advantages of a timber-built ship in its power to resist concussion on rocks and fouling, so that it may be sent on a foreign station for three or four years without being docked, it will be superior in strength, of greater internal capacity, more free from leakage and other inconveniences, will sail faster because of less weight, and will cost less money both in building and keeping in repair. Such a trial, if successful, will remove the greatest objection now affecting the progress of iron ships, to the great benefit of the Government and the merchant service of this country.

R. Mallet, Esq., C.E., F.R.S.—The honour of having been asked to make a few remarks upon the paper which has just been read has, no doubt, been done me from the fact that several years since I myself made some researches on the subject of the corrosion and the fouling of iron, which have been published in four different Reports by the British Association for the Advancement of Science in the years 1839-41-43 and 49; and although not an iron-ship builder, yet having, as a civil and mechanical engineer, and for several years the active partner of an engineering firm, been familiar all my life with the practical applications of iron, and especially with its uses in the form of structural works of plate and angle iron, &c., &c., often as much exposed to corrosion as iron ships, so I am enabled to form a practical judgment on the subject brought to-night before the Royal United Service Institution. The importance of the subject itself, as Mr. Grantham has stated, I think it would be difficult to overrate; for, highly important as the corrosion and fouling of iron ships has been at all times to the mercantile marine in a money sense, it becomes of far more vital importance now that iron ships are certain to be applied for war purposes; for if it be a fact that a war ship sent to sea, after some six or eight weeks loses a mile an hour of her speed from alteration of the surface of her immense hull, or, as we may call it, from fouling,—if a vessel so circumstanced be caught by a clean ship of the enemy that has got the mile an hour still, the former is taken at a disadvantage which nothing can make up for, and so the mere state of her surface determines whether she can keep the seas or not. Hence this question of fouling has become a national one.

There are three aspects or three directions in which perhaps it will be well to make a few remarks in opening the discussion on this paper. The subject has its bearings of a directly chemical or physical character as respects corrosion and as respects fouling, and it has a practical character

as regards construction, that is to say, in what way, and to what extent principles determined by the chemist and physicist, can be practically carried out by the shipbuilder.

As respects the first, it will be perhaps advantageous if I very briefly lead back the attention of those who may not perhaps at all have considered the effects of corrosion and fouling, to a few of the fundamental facts of the subject, ascertained by myself principally, I may say; indeed, I hope I shall not be guilty of any immodesty were I to say altogether; for, so far as my knowledge goes, those four reports of mine up to this present embrace almost the whole of the scientific literature that exists on the subject of the corrosion and fouling of iron ships, and of iron generally.

Iron is only acted upon in the way of corrosion by water, whether it be fresh or salt, that also contains air in combination. All the water we find in nature contains a certain quantity of dissolved air, and the air it does contain—combined in the same way that we find the carbonic acid is in a bottle of soda-water—possesses a larger proportion of oxygen than exists in the air we breathe, *i.e.*, in the atmosphere. If a piece of iron be placed in water from which this combined air has been exhausted, whether the water be salt or fresh, at the ordinary temperature, no corrosion takes place; but if it be exposed to the action of water with this combined air, or air and water together in any other way, or to each alternately, then corrosion does take place; and up to the present hour science has failed to devise any means by which that corrosive action shall be completely arrested. All the various devices of coating with other metals, such as with zinc, usually called galvanising, are found to be perfectly nugatory, under the above circumstances of exposure and constant moisture. Even in perfectly pure fresh water, galvanising—coating the surface with zinc—is a palliative of corrosion and no more. In sea water it is entirely useless, and as applied to iron ships it would be absolutely hurtful, because, independent of any ill effects upon the toughness of the iron, one of the effects of any partial removal of the thin surface coating of zinc is that a thin coating of carbonate of lime is rapidly deposited upon that which remains, and upon that excessively thin bed of lime fouling takes place immediately—plants and animals readily attach themselves to it.

I do not despair, however, of science hereafter being enabled to make an iron ship as invulnerable to corrosion as if it were a piece of platina. I may just illustrate the conceivability of this by repeating a very simple experiment, first due to Professor Schoenbein of Basle, the discoverer of what is called the passivity of iron. Here are two pieces of common sheet iron, and a piece of platina. Here is an acid which is capable of rapidly corroding and even dissolving a piece of iron in its ordinary condition when plunged in it directly: this acid does not act on platina at all. If, however, in place of putting the piece of iron into the acid directly, in which case it would instantly begin to be acted upon, I touch it first with the piece of platina, and immerse the two together, and then withdraw the platina, the iron remains in the acid in a perfectly passive condition; the acid, which is capable of dissolving the whole piece of iron in a very few minutes, does not now act upon it at all, it remains as passive and as incorrodible as does the platina itself. Further, if I now take another piece of iron which has not been touched by the platina, and touch it with the piece which has

been already touched and immersed, it will be found that the latter piece of iron is now in the condition to bring another piece of iron into the same condition with itself, and so in its turn this second piece would not be acted upon; and so we might go on for ever. But if I put a piece of iron which has not been touched by the platina, or by another piece of iron so touched, into the acid, it will be acted upon directly; and if I touch it now with the platina while in the acid or withdrawn from it, this will not now prevent its being corroded, nor arrest the corrosion that has commenced. This little experiment suffices to show that iron, one of the most singular bodies amongst all the elements with which we are acquainted, marvellously endowed with properties fitting it for the uses of man, has yet unseen and undiscovered properties, such as those Bacon talked of long ago, when he said nature still containeth secrets more marvellous and potent than the wit of man hath yet conceived, much less discovered. It indicates the possibility that iron still contains secrets within it that may enable it to be made into an iron ship incorrodible in water, although without any external protection whatever. Indeed, did the passivity of iron extend to the chlorine compounds, as it does so far as is yet known only to the oxygen compounds, the end might be at once accomplished. By experiments carried on in Kingstown Harbour and in various other places upon the actual rate of corrosion of exposed surfaces, say a square foot of iron, for lengthened periods of three or four years, I have ascertained the rate of corrosion for iron, cast, wrought, and steel, from various makers, of different qualities, in various conditions, and in various waters, such as fresh and salt, and each both pure and foul by sewage, &c.; and I may state as one result of these experiments that the rate of corrosion for wrought iron in clear sea water—I am now talking of average iron, such as is used for ordinary ship building—would be such that, corroded on one surface only, six-tenths of an inch in depth would be taken away in a century. That is the rate at which an iron ship in sea water will corrode if not protected by paint or anything else. If protected by certain varnishes or coatings, the progress of corrosion may be enormously retarded.

The Chairman.—Six-tenths of an inch in depth?

Mr. Mallet.—Yes; six-tenths of an inch in depth in a century. That is to say, if the plates were six-tenths of an inch in thickness, and acted upon on one side only, the iron would be all gone in a century. This supposes that corrosion takes place uniformly and alike all over the surface; but that condition does not hold as respects the surface of an iron ship; there are parts where the action is much more rapid than at others, and round the rivet seams corrosion takes place, *cæteris paribus*, much more rapidly than anywhere else, from the rivets being harder owing to the process of closing, than the rest of the plate, and hence slightly electro-negative to the plates of the ship, or in the like relation to them as a piece of copper. It was long ago ascertained by Professor Edmund Davy, nephew of the celebrated Sir Humphry, that iron possesses the property of being protected, by zinc attached to it in mass, in the same way that Sir Humphry Davy showed years before that copper sheathing could be protected by zinc protectors. I ascertained that the hull of an iron ship could be protected to a very great extent from that universal corrosion which takes place, by the attachment in mass of a surface of zinc, only

extending to $\frac{1}{120}$th of surface of the exposed iron. But that will not stop such corrosion of an iron ship as goes on close to where the wash of the paddle-wheels affects her sides, nor near the bows, and other parts where the air and water are constantly agitated and renewed in contact with the iron, and fresh surfaces of the latter constantly exposed by the washing away of the rust already formed. The moment you produce protection with zinc, however, you get a deposit upon the surface of the iron of carbonate of lime in crystals—calcspar, in fact, in the ordinary rhombic form—produced by decomposition of the salts of lime in the sea water; and so the groundwork for fouling is at once laid, and it increases then at an enormous rate. I further ascertained that if the rate of corrosion of iron in an iron ship—the iron plates alone being exposed to sea water, be represented by a number equal to 8—then, if exposed in contact with copper, such as copper sheathing, in the proportion of two to three, that is to say, three square feet of iron to two square feet of copper, in that case the rate of corrosion will be increased in the ratio of 11 to 8, the iron corroding alone at the rate of 8, but at the increased rate of 11 if it be in contact with two-thirds of its own surface of copper. But I ascertained a further fact, which is an important one. Ordinary gun-metal, such as is used for the screws of our propellers (alloys of copper with 8, 10, or 12 per cent of tin), possesses the power of increasing the corrosion of wrought iron enormously more than pure copper itself, so much so that if the three square feet of iron we were talking of were in contact with two square feet of gun-metal, the rate of corrosion is increased, not from 8 up to 11, but from 8 to 19. In connection with this fact I may observe that I have seen it stated that a great number of the iron ships now being sent to sea, or in preparation for sea, by the Admiralty, are fitted with gun-metal propellers. If such be the fact, anything more injudicious or more uselessly destructive to the iron of an iron ship can scarcely be conceived, nor anything more unnecessary. Every marine-engine maker knows perfectly well that cast-iron propellers, or wrought-iron propellers, may be made perfectly safe, weight for weight, with those of gun-metal. It is hard to see, therefore, why this material, that costs about 2*s.* a pound, should continue to be used, where a material which costs about 3½*d.* or 4*d.* a pound ought to be used instead; the dearer material being positively mischievous to the iron ship as well as to the screw-bearings, &c. I also ascertained that among the conceivable alloys of copper and zinc with which an iron ship might be covered, was one closely approaching to the alloy known as Muntz's metal, but not identical with it. This was an alloy of four atoms of copper to one of zinc, very nearly the composition formerly known as Dutch brass. It is a remarkable fact that the galvanic action on iron in sea water of this particular alloy is almost *nil*. A vessel coated with such an alloy, the surfaces being in the proportion of 3 to 2 as before, the rate of corrosion of the iron is only accelerated in the proportion of 9½ to 8; the iron is hence very little worse than if not in contact with any electro-negative metal at all. So far as the chemical properties of this alloy are concerned, it might be applied directly, therefore, to sheathing an iron ship; but any attempt at coating an iron ship directly with any metal sheathing is quite out of the question. The mechanical difficulties are insuperable; you cannot attach sheathing firmly

to the skin of an iron ship in any way, but you injure the strength and diminish the safety of the ship enormously. There is another class of facts to which I may briefly refer. The rate of corrosion of iron in sea water greatly depends, other things being the same, upon the quality of the iron; I do not mean the quality of the iron in the sense in which we usually apply the word in the market, namely, the very best iron as regards toughness and strength. Here is a fact, ascertained by several years' exposure of large surfaces, and therefore reliable,—that an equal surface of the hull of a ship built of the common plates known in commerce as "boat plates"—the worst class, in fact, of Staffordshire or Yorkshire plates—will corrode in a given time at the rate of 36, while an equal surface if made of the very best plates of cold-blast South Wales iron will corrode only at the rate of about 8½ to 9; and that if the plates are of very highly-wrought iron worked over and over again, such as faggoted scraped iron when rolled into plates, or Low Moor or Bowling iron, then the rate of corrosion will be only 2½ in the same time for equal surfaces. It is hence apparent how much is lost in durability and in freedom from corrosion and fouling as well as in strength, by the too prevalent use of inferior qualities of iron for shipbuilding. I will now drop the question of corrosion and come to that of fouling. The two, however, are inseparably connected, and for this reason, that if it were possible to get the hull of an iron ship into a condition that it would not corrode at all, there would no longer be any difficulty about preventing it from fouling at all. It was years ago ascertained by Prinsep of the India Service—

Captain HALSTED, R.N.—Which of them?—because there were several brothers.

Mr. MALLET.—James; he was attached to the Calcutta mint. He ascertained the fact that, if you oil or coat a surface of iron with any greasy varnish or with any shiny material, such as the native Sylhet varnish of India, or even with common drying oil—so long as a vestige of such a coating remains upon the surface, none of the lower forms of animal life attach themselves to it. The cause is apparently a purely mechanical one. The surface is so smooth that the animal is not able to attach himself—the smallest wash of the water washes him off. But whatever be the cause, if we could get that sort of greasy material or any varnish to stick to iron permanently, we could prevent the fouling; but no coating has ever yet been devised that will accomplish this. Innumerable coating compositions have been proposed. I have myself a list, made for me some months ago, of about seventy patents that have been taken out, since the date of my British Association Report of 1843, of different nostrums for preventing the fouling of iron ships. They are all failures; not one of them has answered, not even excluding my own, which was the origin and predecessor of them all. And I may mention further: there is not one of these patent compositions that is not simply ringing the changes upon what was originally proposed by myself. In 1843 Mr. William Fairbairn and I patented a mode of preventing the fouling of iron ships. It was based on lengthened observations I had made as to what were the conditions under which animal and vegetable life attach themselves to iron ships, and what were the conditions that would be

disadvantageous to both. My researches were conducted upon many of the lower forms of marine animal life; and I was then enabled, by living on the seashore, to carry them out with the necessary accuracy and facility. I experimented on oysters, sea-anemones, mytilus, balanus, lepas, patella, and several other forms of lower marine life, besides vegetable marine forms —such as fuci, confervæ, byssus, &c. I found this curious fact with respect to these lower molluscous animals: that the soluble poisons, provided these creatures are very slowly accustomed to them, do not seem in any serious degree to affect them. I had some of these animals in glass jars for two or three years, with constantly renewed aëration of the sea water. At stated intervals a few drops of some soluble poison—for example, sulphate of copper—were dropped into some of the jars. At last I had oysters living in apparent health in a solution of sulphate of copper, which, if any one of us were to drink half an inch deep out of the glass, would have poisoned us, or produced vomiting. The animals became so thoroughly impregnated with copper, that, if you thrust a common penknife into one of them, and let it remain in his body a short time, the blade came out coated with copper. The oysters themselves did not seem particularly annoyed for lengthened periods, provided the process was conducted exceedingly gradually; they all, however, contracted in bulk, and died when the poison reached a certain amount of concentration. If you were to put an ordinary oyster, not accustomed to these bad habits of poisonous dram-drinking, suddenly into the same coppery water, it would die within a very few hours. The facts are analogous with the well-known powers of passive endurance of all the lower forms of life. The same, however, does not hold with poisons of an insoluble, or, rather, difficultly soluble, character, put in a solid but finely-divided state in contact with such animals. An oyster or sea-anemone put into a jar of sea water, into which were dropped a very few grains in fine *powder* of—say, realgar or sulphuret of arsenic, and stirred up, is sure to be deprived of life; it could not exist under such circumstances many hours. The solid grains of the insoluble poison appear to be brought into the fine cells of the branchiæ—such as the beard of the oyster—and he has not the power of eliminating them, and the animal is poisoned, by the irritating contact probably. Whether that is the explanation, I am not naturalist enough to know; but I can vouch for the facts. My method, which Fairbairn and I patented, was based upon these. It consisted in coating the iron plates, after they had been thoroughly well heated by lighting coke fires under the bottom of the ship in dock, with boiled coal-tar chiefly, and on that was laid a slowly soluble varnish, a sort of metallic soap, containing difficultly-soluble poisonous matter. It was mainly formed of common bright varnish, coal-pitch, soft soap, and the poisonous matters, several of which were proposed; but the one which I advised as best was "realgar," or sulphuret of arsenic. I went to Liverpool to see the iron-ship builders, and, amongst others, the late Mr. Laird, with the view to get them to adopt my method. At that time the ship-builders, one and all, said, "Oh, iron ships do not foul at all, and as to corrosion they will last for ever; but in any case" (one of them told me) "we do not want your method, we have some of our own that will do as well." A few months afterwards I found that a vessel had actually been coated at Liverpool. I succeeded in obtaining some of the

coating, and I found that it consisted of bright varnish, tallow, flowers of sulphur, and white arsenic—that is to say, it was precisely the four ingredients of which my patent consisted, only combined in another shape. All similar compositions that are now used, and which have the best reputation, consist of partially insoluble salts, either of copper or arsenic, or of both, mixed generally with a lot of nostrums which are of no use whatever. They are at best mere palliatives, for it is a fact that they all do foul, after a time longer or shorter, over the whole surface. The stuff gets stripped off by the washing of the water, or accidentally, and as soon as that takes place the remaining portion begins to get coated with a thin film of carbonate of lime, deposited from the lime in the sea water; and the moment that deposit takes place the surface becomes a fit nidus for the lower marine animals and vegetables, and then fouling goes on. We therefore come to this conclusion, that some better method is wanted for the protection of iron ships than is afforded by any chemico-mechanical method of coating yet proposed. Now, I would make one or two remarks of a purely practical character upon what Mr. Grantham has brought before us. To prevent any misapprehension, I wish to state that I have no personal interest in Mr. Grantham or his patent, direct or indirect; I stand here by invitation of this body, to which I have the honour to belong, simply to state, for the information of those around me and for the good of our common fatherland, whatever knowledge I have acquired applicable to the subject. Mr. Grantham's method amounts to this: we must all admit that if we could put an iron ship into a water-tight wooden saucer of her own form, and let her go to sea in that wooden casing, corrosion or fouling could not take place on her bottom; whatever happened must happen to the wood. The question therefore is, can you make a water-tight wooden saucer round an iron ship? Mr. Grantham proposes to do so, and, for anything I see to the contrary, I think he can succeed. His method is this: he spaces over the skin of the ship a number of dovetailed ribs of iron riveted to the skin, and between these he drives in, and caulks water-tight pieces of wood; the dovetails hold them on without piercing the skin anywhere, and the caulking makes the wood skin water-tight; over all this he places what other metallic sheathing seems good to him. I conceive there can be no possible doubt that pieces of wood may be driven into dovetailed recesses of that sort, with no more skill than that of ordinary shipwright work, so as to make them practically water-tight. When such a wooden surface is coated over with another of planking, properly secured with felt or tarred paper between, and also caulked, I can scarcely conceive the possibility, while the hull remains sound, of water finding its way inside. But if the sea water should find its way in, the amount of corrosion that could take place, unless there were a stream of water in and out so as constantly to renew the agents of corrosion, would be next to nothing. I have already shown you that if a piece of iron be put into water already robbed of combined air, or if you exclude the air from it, it will not corrode at all. Therefore, if water should get in and lodge behind any one of these blocks of wood, unless it be perpetually renewed by a stream in and a stream out, the water that has got in there will, after a short time, have next to no power in the way of corrosion. I understand from Mr. Grantham that the outer planking will be secured by brass screws.

Mr. Grantham.—And the seams would be caulked as well.

Mr. Mallet.—So I heard; but it appears to me that if these inner blocks were fitted and driven in dry with a reasonable degree of accurate workmanship, they would become water-tight without any caulking whatever. This first coat may be sheeted with brown paper or felt under the planking, and then the planking applied and that caulked. I would then ask, is there any objection to putting on the outer planking with wood trenails in place of with brass screws, as here shown, for in that case there would be absolutely no metallic contact of any sort between the copper or other sheathing and the skin of the ship.

Mr. Grantham.—There would be no metallic contact.

Mr. Mallet.—In that case I take it that the copper would produce no effect on the ship. The copper would itself be exposed to the action of the sea, and would be in the condition of the copper of an ordinary wooden ship. Let us now suppose that the ship grounds, or rides over her own anchor, and tears a large piece of the wood coatings off her bottom. It would have to be a very heavy grind, indeed, to strip off the inner blocks, because every block supports every other, and, therefore, you would have to break off many of the rib irons in order to dislodge any of the blocks. But suppose several of them were broken off, and exposure made down to the skin of the ship, I make no doubt but that then the exposed portion of the skin of the ship would corrode much more rapidly than if there were no copper present because there would then be metallic contact between the copper and the exposed portion of the vessel, made good by the sea water. But then comes the question, *how much greater* that would be. I have mentioned the fact that iron and copper, being in the ratio of 2 to 3, the increased rate of corrosion is in the ratio of 11 to 8. Now, something more than that would be the increased rate at which corrosion would take place in the case supposed. I would merely say this much further, that there would certainly be no such amount of corrosion as to endanger the safety of the ship at sea before she could get home, or into some port where the accident could be repaired. I may mention, in explanation to such chemists as may be present, that in sea water, after exposure for considerable periods of time, the rate of corrosion of iron in presence of copper, or other electro-negative metals, does not follow the law of voltaic equivalents. It may appear strange that copper and iron put together into sea water should corrode in the ratio of 11 to 8, and not in the ratio of the voltaic equivalents. The fact is, however, that the surfaces of both metals when left to themselves in sea water get coated more or less with various insoluble sulphates, and other salts and oxides, derived both from the iron and from the sea water, which alter altogether the rate of corrosion that would otherwise take place were chemical action quite unimpeded. One or two other thoughts of a practical character occur to me. It would appear, with respect to these inner blocks, that there are some woods of which they ought to be, and some of which they ought not. I am quite clear that they ought not to be of pine wood. Pine wood is capable of getting rapidly into a condition of softening and incipient decay on its surface; in that state it rapidly decomposes the sulphates present in sea water, reducing them to sulphurets, which are again decomposed by the iron, and powerfully increase corrosion. Such very soft woods, unless

resinous or thoroughly impregnated with creosote, ought not to be adopted. Oak I object to, because, as every one knows, it rapidly acts on iron in contact with it, getting black and hard. It appears to me that a tough timber, elastic, and tolerably hard, would be the right thing. In fact, I doubt if anything better may be found than refuse teak out of the yards, or perhaps Honduras mahogany. For the outside sheathing it does not matter what timber is used, because it only touches the edges of the dovetail ribs. If this sheathing were made of fir these edges might be exposed to a very limited extent to the objectionable action of the incipient decay of pine timber. Therefore, I think it would be found advisable to put a little more iron into this part (pointing to the dovetail heads of the ribs) and so allow for that. Then, the question comes, what effect would be produced upon the inner blocks by the working of the ship. Having given that point some consideration, I doubt that there would be any objectionable effect produced. An iron ship works in more ways than one. At sea every ship vertically works up and down; it also twists. In wooden ships nothing could be more remarkable than the extent of the latter movement. I recollect reading of some old ship of Collingwood's, the stern of which, when she rolled, tumbled over 8 or 9 inches on each side from the looseness of the framing. That is the sort of motion which would be most likely to dislodge these blocks—not by any single motion, because, if you suppose the "Warrior" twisting even 8 or 9 inches, the effect of any one such movement on any block would be perfectly imperceptible, but, if that sort of working were continuous, it would be difficult to say how far it might result in gradually loosening the timber at last. This is a conceivable possibility, but I do not adduce it as a real or tangible objection. Our ships ought not to work or strain, and my own impression is that not any of these blocks would work loose. I think I have nearly exhausted the observations which it has been desirable to make, unless something should arise in the discussion, when I would ask permission to make further observations. In conclusion, I would say that Mr. Grantham's invention seems to me well deserving of a trial upon a large scale and in an effectual manner. Such a trial can, in fact, only be instituted by a Government department—such as the Admiralty.

The Chairman.—Will you allow me to offer your thanks to Mr. Mallet before we proceed. He is not an ordinary speaker on the subject. He has illustrated and explained it in a manner which only a man can do who is master of the subject; and I think he is entitled to our thanks for the information he has given us. We will now pass on to the discussion.

Captain Halsted, R.N.—Last year I expressed my own conviction, which has never been altered since, that this is a mechanical arrangement which seems to be the most practically available that I have seen. All I would say upon it is this: I would advise Mr. Grantham not to give up one single hair's-breadth in the way of the reduction of the iron plate in order to accommodate the exterior lining, because I believe the advantage of such protection as would be given is a thousand times more than compensated by the advantages to be gained by loss of weight, that is to say, if it increased weight upon the structure of a ship would be 280 tons, by all means make the ship 280 tons larger to carry it. Nothing can exceed the misery of the circumstances in which we are now placed. We ought never to have arrived at it. There has never been a national effort made, nor any combined effort, to prevent an injury

which is absolutely destroying the application of the most effective material for the ships of the Navy. I regard it as a great disgrace to the whole country that such a state of things should exist, and I am perfectly persuaded that by this time we ought to have ascertained that the thing is remediable by chemical application, or to have ascertained under what conditions it can be placed to effect a reduction of the fouling. If that is impossible, then we have got other resources to fall back upon, that is to say, you can make a substitution of metal. Mr. Mallet has mentioned Muntz's metal. Muntz's metal has been shown to be perfectly equal in strength to iron, and the question is of that importance that I do not think the matter of expense ought to enter into the consideration. I do not think any expense can equal that of being obliged to forego the actual use of iron ships, for if a ship has to leave her station in order to be cleansed, she is unserviceable on her station for the time, and nobody knows what might happen when she is absent; therefore I do not think the question of expense ought to be entertained at all. Mr. Grantham here proposes a mechanical mode of rectifying our present position, and I have no hesitation in saying that, so far as an unproved thing can be judged of, because we have no experience in it, I think it is eminently deserving of application; and as we have at the present time a new kind of ship which is about to be commenced, and which is to be made the subject of experiments, I would advise Mr. Grantham to press very hard to have his application applied to the bottom of Captain Coles's cupola ship. I am strongly of opinion that Captain Coles would not make the slightest objection; on the contrary, if the method has the effect of maintaining the efficiency of his ship infinitely longer than otherwise she could be with a bare iron bottom, I believe Captain Coles would jump at it. Moreover there seems to be a desire on the part of the Admiralty to make that ship an experimental ship for more purposes than one. I see they are going to apply one or two different modes of fixing the armour-plates, and I should advise Mr. Grantham to make a set at that point. There is also this suggestion which I would make to him, which is, the use of Muntz's metal and not of copper. It is a mere routine we have got into with regard to the use of copper. The whole mercantile service of the country use Muntz's metal instead of copper. It is infinitely better, it is absolutely cheaper; the restoration or re-construction of it when it is worn is quite as easy as that of copper. Our establishment down at Chatham, where we make all the copper for our ships, is just as available for making Muntz's metal as it is for making copper. I had Muntz's metal in use on a ship which I commanded. At the time when screws were first introduced, before we adopted our present mode of lifting the screw, we used to withdraw it; the ends of the shafts were then left exposed, and the galvanic action was very powerful indeed. The series of experiments to which Mr. Mallet has referred were then made, for the purpose of ascertaining whether any other mixture would exhibit less powerful galvanic action than that which was done by the copper, and all the aft-part of our screw-ships, up to the year 1853, were sheathed with Muntz's metal. The ship I commanded was sheathed entirely with Muntz's metal. I preferred it, and the bottom of my ship was cleaner than those of the other frigates with which I was lying.

Dr. Percy, F.R.S.—I have listened with great attention to Mr. Mallet, and have been struck with many remarks, and with none more so than those which related to the purity of certain qualities of iron. I think Mr. Mallet stated that certain descriptions of iron which were known to be most pure, resisted corrosion most effectively. If that be a fact, it is one of very great importance, because I believe that this particular kind of iron would be found to possess the very highest degree of tenacity, and to be, therefore, the best possible iron for use in structures of this kind. It appears to me that the subject is very far from being exhausted. Although many experiments have been made on the application of various kinds of cements, and although many patents have been taken out, and, as is customary, the same thing has been patented over and over again, still I cannot help thinking that an experiment of a very important character yet deserves to be made. I should like to have heard what Mr. Mallet's experience was as to the application of metallic coating. I think he condemned them all without any reservation. I do not know myself whether many experiments have been made. If they have not, it certainly seems desirable that something of the kind should be done—such as the application of arsenic. It is quite possible to apply arsenic in more ways than one to a surface of iron, and not only arsenic, but other metallic bodies. It may turn out that these applications are useless; but until we have the experiments, we are not in a position to speak with any degree of authority on the point. With refer-

ence to the remark which Captain Halsted made upon the substitution of Muntz's metal, I think that is a subject of very great importance. It is a subject about which I have recently placed my own views on public record; therefore I will not detain you with any remarks thereon.

The CHAIRMAN.—Perhaps you concur in Captain Halsted's views?

Dr. PERCY.—I am not prepared to say that. I think it is a subject worthy of more attention than it has yet received. Probably the Admiralty have some good reason for preferring copper. I believe in the case of Muntz's metal it is necessary that the vessel should be examined and repaired after a comparatively short time.

Captain HALSTED.—No, that is not so. It is almost universally adopted in the merchant service, and I have had it in my own ship.

Dr. PERCY.—How long without cleaning? That is the point.

Captain HALSTED.—We were more than two years before we were taken into dock.

Dr. PERCY.—Is not that a short time for vessels of war?

Captain HALSTED.—She was not taken in purposely for it; she came into dock accidentally, and, when she did come in, arrangements were made for an examination of the amount of fouling as compared with copper. The result of that examination is with the Admiralty.

Dr. PERCY.—The explanation of that is, that the zinc is perpetually dissolving away, so that the hold of these animals is prevented. In the course of time the whole of the zinc disappears; so you see, here corrosion plays a very important part.

Captain HALSTED.—It may depend upon the amount of metal; but in the case of my own ship I know that the report now exists, and I know how very little we had to do, because we had a clean bottom when the ship was taken into dock.

Dr. PERCY.—That leads me to another question about the effect of corrosion in the way of preventing the attachment of these shells, &c. One would think, *à priori*, that in proportion to the degree of corrosion would be the difficulty of attachment. I do not know whether I am right in my view. A certain amount of corrosion, I believe, would be desirable in cases of this kind, unless you have that degree of absolute smoothness to which Mr. Mallet has called attention.

GEO. TURNER, Esq., Master Shipwright, Woolwich Dockyard.—I do not think the copper sheathing is altogether free from fouling. I recollect a case in which we took off about ten tons of mussels from the bottom of a ship.

The CHAIRMAN.—It is a question of degree.

Mr. TURNER.—I have known copper on the old "Royal Sovereign" (it was pure copper then; we have lost the making of it) that had been on twenty-one years, and there was no diminution at all. How to account for it it was impossible to say, but such was the fact.

CHARLES ATHERTON, Esq., Chief Engineer and Inspector of Machinery, Woolwich Dockyard.—I will not attempt to detain the Meeting, but I would remind Captain Halsted of an experiment which was made at Woolwich fifteen years ago, when an iron boat was covered with an adhesive kind of kamptulicon about an inch thick, and on this a complete surface of copper was laid by adhesion, and it was very difficult to take it off. The experiment was not completed, but it shows that something of the same kind might be made applicable to sheathing the bottoms of ships. I believe that it is admitted that bitumen is the best material for adhering to iron. With regard to those experiments which Mr. Mallet has brought forward to-night, I would not think of turning such things into ridicule, but the experiments are so wonderful that it almost makes one suppose that a clever fellow can produce any results he pleases. There is one curious thing about the connection of brass and iron. I have been in the habit of breaking up boilers that have been tubed in brass—brass tubes in iron plates; I do not remember to have seen any of the plates the worse for the brass tubes fitted in them.

MR. MALLET.—Assuming the fact, a scientific explanation of it is not difficult nor inconsistent with anything I have stated. The iron pans in which salt is prepared in the Cheshire Salt Works, evaporate boiling brine, and yet are acted upon scarcely at all. Water holding a saturated solution of salt contains no air, and this is exactly in accordance with what I explained at the outset, that iron placed in water from which combined air has been exhausted, will not corrode. That is more or less the case in every marine boiler. But the more efficient cause which protects the brass tubes, and every part of the interior of a marine boiler is, that before the boiler has been in action six hours a stony deposit (insoluble salts of lime chiefly) takes place

on the surface, and this protects it from further corrosive action; there is no metallic surface exposed, there being a thin film of deposit between the water and the sides of the boiler. With reference to some remarks of Dr. Percy, I would mention first, with respect to Muntz's metal—and this was one of the things I had intended to allude to before—I see no reason why Muntz's metal should not be substituted for copper in Mr. Grantham's case. Muntz's metal was not the peculiar alloy of no action that I was talking of, which leaves the iron in its nearly neutral condition, but I think Muntz's metal would be an advantageous substitute for copper in this instance, and would produce less effect on the iron in any case than copper would. I would not recommend the fastenings here or anywhere else to be of Muntz's metal, for there can be no more deceptive or unsafe metal for bolts or other fastenings than it is. In the course of time it gets into a crystallized condition, and a bolt that will bear nineteen tons to the square inch when first rolled, may in the course of a few months, or even a few days, break as easily almost as a piece of crockery. Dr. Percy has asked me a question with reference to metallic coating. In speaking of metallic coating, I alluded only to galvanizing—coating with zinc, or with zinc and tin.

These have been tried, and found ineffective in sea water, for reasons which I have before alluded to; but I entirely agree with Dr. Percy, that the subject of modifying the substance or surface of the iron is not exhausted; that a great deal might yet be done in the way of carefully and really scientifically-conducted research, with such means given to assist experiment as the public departments can alone supply, and not by the voluntary labour and research of private individuals, as was my case. My experiments were made purely for the sake of knowledge, and at the expense of the British Association, which spent £300 or £400 upon these experiments; but such experiments, to be conducted right, would need larger amounts, and the appliances which the public dockyards could afford to be placed in the hands of scientific men. Another direction of inquiry is open, which Dr. Percy, talking of this and analogous subjects a few days ago, stated to me. He, I believe, holds the view that a large field of inquiry exists as to how far certain minute alloys of other metals mixed with iron for ship plates might be attended with an available diminution of corrosion and also of fouling. It is a fact, as I have mentioned, that the purest iron corrodes by much the slowest, and that such iron therefore makes the best as well as the strongest ships. The quality of iron that is commonly used for iron ships, called boat-plate iron, is not only the worst mechanically, but the worst chemically. But it remains still for the chemist, the metallurgist, and the engineer together, to discover whether it may not be possible to make some compound of iron of this best quality, with another metal in small proportion, that as respects the ends in view shall be best of all.

The Chairman.—It is really a very important subject, and we were turning over in our minds whether we could not find a day to carry on the discussion. We are very much indebted to Mr. Mallet and Dr. Percy for the very pertinent facts they have brought forward to-night. When we were discussing the subject of iron ships, a number of facts, which then appeared to be opposing facts, are now explained by the different qualities of the iron, and the different degrees of susceptibility to corrode. If an inferior iron is used, a ship of that description is worth next to nothing; and a ship of the very best description of iron is worth a great deal, and would perhaps be the best description of ship, if only the effect of fouling was disposed of. Since the remark with respect to the loss of a knot per hour in the speed of the Irish boats, I have made a calculation as to the cost. It would be equal to about one-sixth of the whole quantity of coals they burn; and, taking the reduction of speed from fouling the bottom of the "Warrior," as estimated by Mr. Grantham—not at the figures he puts it, seven to twelve—but taking a reduction of speed equal to one-third, it would make a difference of about 50 tons of coal a-day in that ship. Abroad coals are not to be obtained under £2 per ton, sometimes at not less than £4 per ton; but take it at £2 per ton, and there is £100 per day lost by the diminished speed of the vessel through fouling. Now Mr. Grantham's estimate for his sheathing is only £4,000; we see from the above how soon that would be realised in the saving of coal. But, as Captain Halsted justly observed, that is no measure of the ship's performance, because if she has to go 1,000 miles to be docked the whole use of the ship is lost during the period she is away. If she is the type of a fleet, and all the vessels are liable to become thus defective, the whole fleet may require to go away or become weakened, so that the mischief they were intended to prevent may be effected in its absence. It strikes me that this method of Mr. Grantham's is really a complete one. I do not

think it is of that character which requires to be what they call "tested." I am perfectly satisfied with the explanation which Mr. Mallet has given, that there is no danger, no material danger, if only the right description of wood is used, and ordinary care is taken in putting the sheathing on,—I agree with him that no water, in any great quantity materially to injure the construction, can get in; therefore it is really perfect of its kind. It would be paid for in a short time, and the efficiency of the vessel would be preserved. Twenty-five years ago I was on the coast of Africa when an iron whaler came out. She had only been six months out from England. She had been cleaned, as well as they could clean a vessel at sea, every month, with long brooms and ropes, under her bottom; but she had long grass and barnacles of immense size attached to her, in consequence of which she was not safe. She would neither sail nor steer, added to which she was not manageable. Her crew had this enormous work entailed upon them besides their ordinary work. I made a report to the Admiralty on the subject, and, with such before them, it was not to be wondered at that they did not undertake to embark in iron ships: they may be very effective, the iron may be very good, but if they foul in this way they will be useless. It appears to me that this system does get rid of that difficulty. I do not think the seams would open in any injurious degree, for a three-decked ship of the old style only broke her sheer fifteen inches in launching. After the new system was introduced by Sir Robert Seppings, similar ships only broke three inches in coming off the stocks. When you come to divide the largest quantity over the number of these small sections or plates, you will see that it can have no appreciable effect on the joints; and when you consider that the seams of wooden ships are so open that in caulking them you sometimes drive in oakum equal to inch rope, the thickness of the twentieth part of a sheet of paper is really no opening whatever. With the best ship, when first launched, the seams are of immense size as compared with the opening which is supposed possible to arise from the bending of the ship.

We have to return our best thanks to Mr. Grantham for his interesting paper.

Evening Meeting.

Monday, March 31st, 1862.

Captain E. G. FISHBOURNE, R.N., C.B., in the Chair.

ON CONSTRUCTING, MANŒUVRING, AND PROPELLING SCREW STEAMERS FOR WAR AND OTHER PURPOSES, AND THE APPLICATION OF A SCREW PROPELLER CALCULATED TO PREVENT FOULING.

By Commander T. E. Symonds, R.N.

As it is well known and admitted that there are many imperfections in the present method of fitting the screw and in manœuvring and steering screw steamers, more especially those for war purposes, it is surprising that these subjects have not received more notice. It is true that a casual remark has been made as to the necessity for "protecting the screw," and improving the steering qualities; but, as a rule, discussion has been almost exclusively confined to the respective merits of "armour plates" and "guns," as though they were the only two things needful.

All seamen will admit that the objects I have named are not second in importance even to those two great questions; for of what comparative use is a ram or an armour-clad ship without the power of manœuvring rapidly, either to give a blow effectively or avoid that of an antagonist; and can anything more pitiable be imagined than one of those leviathans shorn of its motive power, a helpless log on the ocean, at the mercy of smaller vessels, her screw or rudder disabled, perhaps, by the first broadside of an opponent half her size; or by the wreck of some mast she may have shot away in chase, for, be it remembered, a screw is as likely, or, perhaps, more likely, to be fouled by other ships' rigging and wreck than her own, and, if we are to judge from past accounts and delineations of naval actions, there must be plenty of it floating about at such times.

Although we have the highest authority for it, and common-sense dictates the necessity for rapidity and precision in manœuvring, what advance have we made in that direction to meet the requirements

of the increased proportions of our ships? We find the reply in the published statements of their steering qualities. Reflect for an instant on the time and space it would occupy to turn such a ship as the "Warrior," as now equipped, when at slow speed, and what incalculable damage might be done to her by one or more smaller shot-proof ships capable of turning twice to her once, which, having this advantage in turning, might always avoid her blow. An eminent engineer, on a very recent occasion, remarked that "it was one thing firing at a target and another at a ship constantly moving, and therefore as often offering an inclined plane to the shot as a vertical one. Ships," he said, "would not always accommodate you by placing themselves at right angles." Nothing can be more to the point; and, I add, no man would so "accommodate" his opponent if his ship were under perfect control, but would take that advantage superior manœuvring power gave him, and place her at an inclined angle with his antagonist, either to receive his fire or avoid the blow.

Now, although I admit that some of our screw steamers do manœuvre very fairly under favourable circumstances, there is not one of great length that could be moved with certainty, or anything approaching it, especially at slow speed—and it is at slow speed, I apprehend, that an action would be fought, at least a general one. It is one thing to describe a circle in a fair way and another to turn a ship short round in action. I contend that a perfect fighting ship, no matter whether armour-clad or otherwise, should have the power of turning in her own length, or nearly so, and that the steering power should be as perfect going astern as going ahead; that the propelling power, be it what it may, should be out of danger from shot or ram; and that she should be of such a draught of water as to enable her to go into any of our own harbours or docks without delay, or to stand fearlessly into an enemy's port, and occupy a position that will enable her to use her guns effectively, some means being adopted whereby the rolling is reduced materially, a rifled or any other gun being comparatively of little use unless you have a steady battery to fire it from. The disadvantage of heavy draught of water was constantly felt by our inshore squadrons during the old war, and has been more recently made manifest during the operations in China. With such examples before us need we hesitate to reduce it?

I am strongly of opinion that in ships, as in other machines, special tools are required for special work, if it is to be done perfectly. We must, therefore, make up our minds to throw overboard old notions, and adopt such as will meet altered circumstances, and not attempt to cram into a ship intended for operations in shore the same amount of stores and gear we should put into one intended for cruizing purposes, or to expect to obtain any great results under canvas from ships required to steam at high velocity. It is very clear that some point must be conceded to obtain a special result, and I take it most are now of opinion that any attempt to effect a combination of qualities in ships of the present type will be futile. I believe that masts and sails are necessary to all classes, but only as an auxiliary in case of a breakdown, and to ease the "rolling motion;" they may be adopted without hesitation when the fouling of the screw is obviated, as I am confident it is in the form of propeller described in this

paper. That keeping masts aloft eases the rolling motion is well known to practical men and those who have seen a dismasted ship in a sea way. It is obvious that no vessel without masts can roll as easily as with them, on the principle of the metronome, especially if they have fore and aft sails set with their sheets hauled flat aft, which will reduce the motion even in a calm, and is an expedient often resorted to. I therefore much doubt if ships without masts, as is contemplated, will be as efficient for general purposes as is expected, and their absence will be found very inconvenient in hoisting in and out heavy weights, fishing the anchor, &c.

Cellular Girder System.—At this point I consider it right to observe that Mr. Roberts was, so far as I can ascertain, the first to recognise the necessity for giving greater longitudinal strength to iron ships, and to promulgate this doctrine in his patent of 1852 (and on many public occasions), in which he compares a ship to a "beam," and that as a beam (which increases in strength as the square of its depth, or nearly so) it was desirable to increase the sectional area of the iron in the upper part of the hull, and thus secure the utmost strength due to the whole depth of the ship's side from gunwale to bilge.

This conclusion was arrived at on noticing the weakness exhibited by iron ships of great length building at that period, the iron sides of which terminated at the deck, the top side being composed of wood of very light scantling, thus losing several feet of depth, and consequently a large proportion of strength on the upper side of the ship or beam.

Recognising the applicability of the cellular girder system to these iron ships, he next sought a mode of arranging it, by which the greatest strength could be obtained where it was most required, viz., at the top and bottom, without a corresponding increase of weight or interfering with existing arrangements.

Novel Mode of applying Girders.—Instead, therefore, of introducing girders under the deck, and consequently some six feet from the top of the ship or beam, as has been subsequently recommended by other authorities, he proposed to make his girders subservient to the requirements of his ship, forming them out of the cabins, saloons, coal-bunkers, and keels, as shown in the drawing of the mid section, sheets 1, 2, and 3; he likewise proposed to make the decks of iron. Thus, as in the lithograph of a large passenger or troop ship (Plate I.), the cabins, or horse-stalls, on either side form a continuous cellular girder fore and aft the ship, the vertical parts being formed of the side of the ship and the face of the cabins, the top and bottom being composed of the iron main deck and a strong covering plate which runs fore and aft, and is connected with the upper deck or platform, the cells being formed by the divisions or bulk-heads of the cabins or stalls. By this arrangement it will be seen that there would be a very great increase of longitudinal strength in the right place beyond that of a girder under the deck. Had the "Victoria" troop-ship been fitted with these girders, her bulwarks might not have been stove in on her late disastrous voyage.

Midship Girder formed of the Saloons, Cabins, &c.—Instead of making the "deck saloons" of wood or of iron in broken lengths, he proposes to make them of iron, forming a continuous girder, B, nearly from stem to stern, connected with the poop and forecastle deck; this would in itself be

sufficient for all practical purposes; the sides of the saloon could be made as those of the cabins, or of a "lattice girder," with advantage, and thus admit of doors, windows, &c., being introduced without weakening the structure. This latter plan has been adopted (the lattice-bar excepted) in many light-draught steamers, but has not hitherto been applied to large steamships, although there are many instances on record, and some of no ancient date, where their presence would have been very serviceable. Plate I., No. 1, shows the arrangement of cabins in the after part of the ship, and horse-stalls in the fore. No. 2 is the deck plan, showing fore part of midship girder, used as horse-stalls, with passage between the stalls; the after part fitted as saloons.

Keels and Bottom.—Having thus disposed of the upper side of the ship (or beam), it became necessary to consider how the lower side could be formed so as to resist an amount of compression more than equivalent to the tensile strength of the upper (as wrought iron does not resist compression as well as it does tension). For this purpose, in addition to the cellular bottom, C, continued the whole length of the ship (and not merely in parts, as previous to his invention was done in some instances), Mr. Roberts applies two cellular keels, D D, of any required depth, one under each bilge, extending nearly the whole length of the floor; these keels, as represented in the lithograph, are "cellular girders," which will not only give the required strength, but effectually defend the bottom plates on taking the ground, especially if fitted with timber false keels. If considered necessary, the bottom between these keels and on either side the bilge might be lined with planking, and thus overcome the objection some entertain to iron bottoms in the event of a ship striking on rocky ground.

Keels reduce Rolling, increase Strength, and do not interfere with Steerage.—These keels will materially reduce rolling, and give general stability and strength to the whole fabric, especially in a longitudinal direction, making it more capable of resisting the shock produced by the ram manœuvre. They are, in fact, two huge back-bones to secure the ribs to, instead of one solid keel of plated iron, which, as is well known, is in every way weaker than one of a cellular form. Being parallel to the plane of the ship, they do not interfere with either steerage or speed, as has been proved in Mr. Tovell's ship, than which a better sea-boat or an easier roller does not, I believe, exist. These cellular keels, in connection with the cellular bottom, may be adapted either for surface or internal condensation, as suggested in Mr. Roberts's specification. It will be seen, by referring to the drawing of the mid section, Plate I., that the ship is divided longitudinally into three parts by iron bulkheads, which extend nearly the whole length, connecting the upper deck with the bottom, the longitudinal compartment thus formed being sub-divided by the athwartship water-tight bulkheads, and by the divisions of the cabins, coal bunkers, and stalls before described.

I imagine that any seaman will at once perceive with what facility a ship fitted with such keels may be grounded on a favourable place, and her bottom repaired or cleaned (should no docks exist), the keels being in fact a gridiron, which may be made even more complete by slinging logs of timber under them. As the ship will remain in an upright posi-

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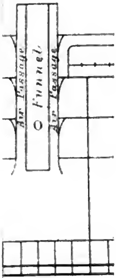

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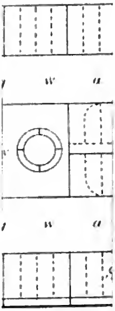

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tion on these broad surfaces, no shores will be required, which, as in the case of the "Great Eastern," might penetrate the bottom; a few spars over the side being sufficient to steady her. The risk of docking heavy ships would also be greatly reduced, the weight being distributed over a large area under each bilge, and the operation materially expedited. In engaging forts, what an advantage it would be to have a ship thus capable of grounding without danger, and fighting her guns with nearly the same facility as though afloat. It would certainly give confidence in approaching fortifications, or covering the landing of troops, and enable them to engage so as to do their work effectually at close quarters, instead of playing at long balls. Merchant vessels in taking the ground would be free from the risk of falling over, and thereby damaging their cargoes.

Weatherly Qualities.—I contend that a light-draught ship fitted with these keels would, from the resistance they offer, have as good or better weatherly qualities than one of deeper draught without them. They are, in fact, to a ship what the two large logs are in the Pernambuco catamaran (a drawing of which is shown in Plate II.), than which there is no more weatherly craft afloat: these catamarans never roll. It is curious and instructive to remark how nearly the intuitive genius of the savage thus approaches, or, perhaps, more properly speaking, has anticipated, the deductions of science.

Light-draught gunboats and mortar vessels might readily be sent over sea without risk, deep temporary keels being added to those already in existence, which might be removed at pleasure.

Although I believe no one can for a moment suppose that any structure would have entirely withstood the tremendous sea which broke upon the "Royal Charter," I question whether such a method of strengthening as I have described would not have held her together long enough to have afforded some chance of escape for many who found a watery grave on that fearful night. At all events, it is worth consideration; for how many tens of thousands are there who have to incur similar risks in the future?

Cellular Girders, as applied to Ships of War.—As the proposed arrangement of girders and bulkheads could not always conveniently be carried out in a ship of war, as has been described for a merchant vessel, it is proposed to fit them as shown at A, Plate II., carrying them up to the upper part of the gunwale—say six feet—or, if preferred, making a shallower girder, as denoted in the drawing, using the space above for hammock nettings, with a gangway round the ship. The cells may be used for stowing light sails and other gear required to be kept on deck.

Increased Strength on Upper Deck.—That some additional strength on the upper part of our iron ships is required, is, I believe, admitted by many, and was strongly advocated at the Institution of Civil Engineers the other day; if not apparent now in our war ships, it is likely to make itself visible if they are subjected to any severe strains either by grounding, being in heavy weather, or used as rams.

Form.—To obtain the greatest amount of capacity consistent with strength and required speed, I advocate a mid section of elliptical form, which is maintained throughout full one half of the length of a uniform depth (being on an even keel); the bow lines being composed of easy curves on a principle by which the best form for entering the water I

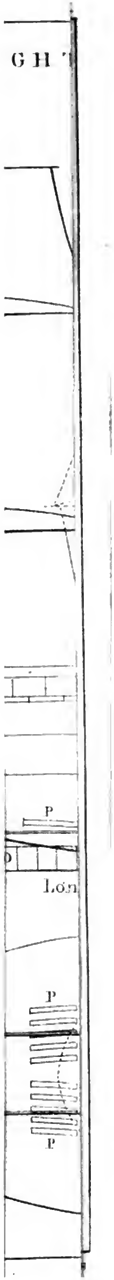
have yet seen is obtained; these lines are of such a character as to avoid any considerable bending in laying on the plates, which is a process attended with great trouble and expense.

This flat elliptical floor is continued to the fore foot; thus the fore-section is made self-supporting (the heavy part of the sharp floor, as in other ships, being dispensed with); it is consequently more buoyant and, combined with the long floor, will reduce the tendency to pitch, and will "lift" in going against a head sea. The after section is composed of convex curves sufficiently fine to deliver the water freely, but not so lean as to diminish the necessary support in that quarter, the absence of which induces a sending to one side or dropping quarterwise, which my observation teaches me is one of the causes of rolling in ships of the present build, which, having the screw in the centre, require, it is supposed, a finer and longer run for the water to close upon it. A lean after section also produces deeper immersion aft when at high speed (or squatting as it is sometimes called), which retards considerably. This form, combined with the cellular keels before referred to, I consider best calculated to produce a steadier platform than has been obtained hitherto, and by a proper adjustment of weights will reduce rolling to a minimum; without it guns of precision are of little avail, and you may as well attempt to fire a rifle at long range from a swing as a rifled cannon from a ship rolling through an arc of 30°.

Increased Bulk and Draught not resulting in Increased Steadiness.—It has been well proved that increased bulk and draught has not decreased rolling as was anticipated, nor have the "bilge pieces" had much effect (except to interfere with the steerage); is it not, therefore, time to try some other means of accomplishing it? It has been said that the "Warrior" is to have a keel similar to other ships to reduce her rolling. If such be the case, and it really affects her, how much more would two? Again, in rolling thus, a ship exposes her bottom to shot, and four feet of armour-plating below the water-line will be of little use.

Elliptical Mid Section.—It may appear at first sight that the section we propose is favourable to rolling; but it is the reverse when ballasted, and provided with two keels, as has been proved in Mr. Tovell's circular section, and may be seen any day by experiment with a barrel or cylinder, which rolls more than any other form when empty, but when ballasted and fitted with a keel, less, and is, moreover, easier in its motion from the fact of the same section being always immersed. It is for experiment to prove which is the best for speed, the circle or ellipse; we prefer the latter, and especially as it enables us to keep our engines lower.

Light-draught Long-floored Vessels advocated.—My experience among the beautiful slavers on the coast of Africa and the best models in our yachts, more particularly those of Mr. Weld, convinces me that a light-draught long-floored vessel is, beyond all doubt, the fastest before the wind. So far was that opinion received among the owners of slavers in the year 1850, that vessels were constructed purposely, with orders never to haul on a wind if chased. As in sailing vessels with the sails acting in a line with the keel, so is it, I believe, in screw steamers; and for this, added to other palpable reasons, do I advocate as light a draught as possible in all war steamships, believing that it will be found in practice,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that, so long as the form is good, an increased width at the water-line with decreased depth (provided the immersed area of mid section is the same) will be more readily propelled than the same area at a deeper draught with less beam. It is clear that the light-draught body is displacing water of less density, and will not throw up that tremendous wave which is observable in most deep ships at high speeds. Light-draught ships are proverbially good sea boats; the old Danish vessels, for instance, our fathers remember, and often quote as being handy and weatherly.

Operations in-shore.—A light-draught ship, whether for war or mercantile purposes, must possess decided advantages over those of heavy draught on numerous occasions, and especially when intended to operate in-shore, when they may there evade them by crossing shoals or bars, and take shelter under batteries (or attack them). Merchant vessels, also, trading to the northern and other ports, having tidal or bar harbours and rivers to contend with, are liable to detention and loss by waiting for water,—Amsterdam and Rotterdam traders, for example. A light-draught ship on an even keel, fitted as described, would possess immense advantage over a long-heeled vessel taking the Brill Bar, where ships often thump for hours and damage themselves aft, as the shock would be distributed over the entire length of the two cellular keels, the draught being the same fore and aft.

Light Draught as Applicable to present Harbour and Dock Accommodation.—A reduction of even two or three feet would obviate much of the delay now often incurred in going into Portsmouth, and other harbours, and reduce the risk. It would also make present dock and harbour accommodation available without incurring the enormous expense consequent on alterations, which, it appears, are necessary ere the present class of large war steamers can be accommodated readily. At all events, a reduction in draught would set at rest the many questions that have arisen as to the ultimate value, or otherwise, of Portsmouth as a port for such a class of ships, and prevent the necessity of dredging a hole for a a deep-draught ship to lay in, as in the case of the "Resistance" at Chatham. The ship shown in Plate II. is of 5,000 tons, having a draught forward and aft of 20ft. 6in., being 6ft. 6in. less than the "Warrior."

Present System of Propulsion Impossible in Light Draught if Speed is required.—It is, however, obvious that the draught cannot be considerably reduced under the present system of propulsion with one screw, so long as great speed is required, for to retain great speed it is necessary to have a screw of great diameter, which entails great draught; and I much question, even with the present draught, if the screw is sufficiently immersed in many ships to produce the best results. In some, having a smaller screw well immersed, a greater portion of duty has been observed. However, be this as it may, if one screw cannot do the work at a reduced draught of water, why not use two? I believe the principal objections to two screws are, that the chances of fouling are multiplied; *that the present form of after-section, with the dead wood intervening, would not admit of sufficient diameter, and offers a great obstruction to propulsion and steerage; and that the speed at which it would be necessary to drive screws of finer pitch would be too high.* Good results have, nevertheless, been obtained, and especially in one case I am acquainted with. The

vessel in question is about 90ft. long, 12ft. wide, 3ft. 8in. draught; having two screws (3-bladed), 3ft. diameter, driven by two single-cylinder engines of 15 horse-power. She often attained a speed of eleven and twelve knots, and proved herself a capital tug, performing in a manner that quite baffles any calculation that is usually applied to ascertain the power of a single screw steamer. This vessel was steered by her screws alone, either going ahead or astern, in the most perfect manner, turning easily and quickly in her own length. Steamers with two screws are largely and successfully employed as tugs in America, and some of the best French gunboats are also fitted with them. Why should they not be here? I am aware that bad results have been obtained in several vessels fitted with two screws, but failure is as often caused by a wrong application of a principle as by any defect in it. In the form and arrangement I advocate, the obstructions due to the present form of vessel being entirely removed, the conditions are altered.

Reasons for advocating Two Screws.—Encouraged by results that have already been attained by steamers with two screws, I have less hesitation in advocating the use of them on this occasion, especially as by the peculiar method we propose to apply them, most of the objections referred to are obviated, the screws we submit being of a form that will entirely prevent fouling; the obstruction of the "dead wood," after stern-post, and rudder being removed, we are at liberty to increase the diameter, and still have free space for them to work in, the water having undisturbed access from every direction. *The rudders are so placed as to improve the steering power without interfering with the screws, rudders and screws being constantly submerged at such a depth as to defend them from shot, prevent their being lifted out of water, or injured by the ram manœuvre.*

Inconvenience attending Present Method of fitting Propeller considered.—Previous to describing this arrangement, I will consider the inconvenience arising from the present method of fitting the propeller, which is well known to be constantly liable to foul, and, therefore, specially inapplicable to war purposes, in which delay is defeat.

The numerous plans that have been suggested as a remedy prove the importance of this question. "Guard bars," "knives on the boss," and a variety of other expedients equally inefficient (which only aggravate the evil), have been laid aside, and still accidents, of a more or less fatal character, are constantly occurring. It was only the other day that one man's life was sacrificed, and that of many others in jeopardy, by the hawser attached to the "Great Eastern" fouling the screw, and in an instant capsizing and smashing a large man-of-war's boat, and precipitating her crew into a tide-race, at Milford Haven.

The frequent accidents and detentions from the same cause are now patent to all; I shall, therefore, not recapitulate them, but proceed to other objections of an equally important character.

Other Objections.—The screw is in most instances so near the surface that it must catch every floating object within its influence; and being lifted out of the water by the slightest pitching motion, and often bared by the undulation of the wave, it loses a large proportion of its effect; and if not fitted with a good governor, the engines are liable to be strained by "racing" (which may be attended with serious results in such engines as

are now fitted to our large class steamers), and often causes a fracture of the blade on re-entering the water after acquiring a high velocity. Being thus near the surface, the screw is likewise liable to injury from shot, and I take it that it would be the target for the first broadside, for, once crippled in that quarter, the ship would be at the mercy of her opponent. Again, being within a few inches of the bottom, it is liable to be broken by striking a rock or any hard substance, as in the case of the "Defence," at Spithead, the other day, on her trial trip.

It is fair to suppose that in going up rivers or entering the narrow seas or channels of an enemy, every means will be resorted to that ingenuity can suggest to cripple an opponent. Among others I know of no more certain means of fouling a screw of any size than mooring trains of nets, with their 4-inch warp attached to them, some feet below the surface, at various distances. They would as certainly protect the approach to a harbour from a screw steamer as anything that could be devised. Some of the skippers of our screw steamers trading coastwise are, I suspect, well aware of this fact.

Screw and Rudder depending on the After Stern-post; their Liability to Damage.—Apart from this tendency to foul, both screw and rudder are entirely dependent on the after stern-post, which is liable to be bent or broken by a sea striking the exposed part of the rudder, the rudder-head being also liable to damage from the same cause, as in the "Great Eastern." This may arise from a defective weld or wrong proportion on that long unsupported bar of iron which is so costly and difficult to forge, and, with its appurtenances, adds materially to the weight at the extremity, where all should be as light as possible. It is also liable to be bent by a blow from heavy shot or ram, or by striking the ground aft, which is by no means an improbability in a long-heeled ship drawing 27 feet or 28 feet of water. In either case the rudder and screw-lifting frame might be jammed, the screw-shaft thrown out of centre, and the ship crippled either for sailing or steaming. The after stern-post displaces a large column of water, and together with the vacuum caused by the stern-post passing through the water, offers a considerable obstruction to speed, while the opening for the screw allows the water which would otherwise impinge on the rudder to pass through and diminish the steering power. This is sometimes felt to a considerable extent when under canvas. The after bearing of the screw being open at the upper side, is liable to catch anything falling upon it, and thus jam the shaft, as occurred not long since to one of our war steamers.

Remedy.—The method we propose for remedying these evils is first by using a propeller, F, which by its form alone is calculated to reject or throw off all impediments, and if striking a hard surface will not receive any serious injury. This propeller may be readily applied to ships of the present type, with or without an after bearing; we prefer the latter. In this case the chances of fouling would be materially reduced, but cannot be prevented to the same extent as in a ship constructed or altered to suit it.

Description of Propeller.—The vanes or blades are of wrought iron or steel secured to spiral flanges on the boss, the flanges being covered by a cycloidal casing of wrought iron; the root of the blades being long, and

therefore well supported, admits of their being made thinner than those of the ordinary shape in cast metal; being thinner, they displace less water, and consequently absorb less power in turning; being of wrought iron, they are far less liable to injury, and can be readily replaced or repaired when damaged. They may be estimated at about half the weight, and one-third or one-fourth the cost, of those made on gun-metal of the same diameter.

Cast-iron or cast-metal blades of this form would be far less liable to injury than those of the ordinary shape, as they would not strike a direct but a glancing blow. These blades are tapered on both the leading and after edges, and when in rotation, whether turning ahead or astern, may be said to form a cone that will throw off any passing wreck chain or cordage without fouling or injury; a coil of rope falling upon this screw would be instantly thrown off. This form of blade will also insure a more constant and equable action on the water under all circumstances, and thereby reduce vibration. It may be applied to vessels of very light draught for river purposes half immersed, as in many American river and lake steamers.

Method of Attaching Propeller to Shaft.—The method of attaching it to the shaft, as shown in Plate I., fig. 5, enables it to be readily shipped and unshipped, and being comparatively light, the after bearing is dispensed with, part of the after length of the screw shaft into which the short shaft of the propeller is shipped, being of increased diameter, so as to give a sufficient bearing to prevent the weight of the screw wearing unduly, and to admit of being bored out to receive the short shaft attached to the propeller, which is secured by a key, gib, and cotters; by this means the screw and short shaft may be removed without disturbing the main shaft or admitting water into the ship.

It will be seen by the drawings that the part known as the "dead wood" in timber-built ships is dispensed with, and with it all the cumbrous and costly paraphernalia of stern-posts, screw-lifting frame, and, in fact, every forging of any consequence, thereby reducing the weight of the after extremity, and the cost of the ship. There being no aperture for the screw, the after section will be stronger and lighter.

Two Screws advocated.—As before stated, I advocate two screws (of the form and character described) having three or four blades; these are fitted to cylindrical trunks, G, under either quarter, which connect the keels with the counter of the ship; these trunks are the same diameter as the boss of the screws, against which they fit closely, so as to prevent anything getting between them, the rudders, H, being attached to the after extremity of the keels, but before and lower than the screws, so that both screws and rudders are quite clear of each other, and are thus capable of performing their respective functions without hindrance, both being immersed at such a depth as to place them entirely out of reach of shot or ram, and prevent their being lifted out of water. Should it be found that these rudders are too close to the screws and impede their action, they may be placed further forward, which will rather increase the steering power than otherwise. It will be seen that by this method of fitting the screws, the water being already displaced by the ship and trunks, it comes direct to the screw-blade and closes by its own gravity

on the cycloidal boss, leaving no appreciable vacuum, whereas in the ordinary mode the boss not only displaces a large volume of water, but leaves a considerable vacuum in its wake, which will absorb power, retard speed, and, I am inclined to believe, cause vibration.

Manœuvring.—Being right and left screws, they turn in opposite directions, and therefore correct that deviation from a right line either would produce separately (as is well known); thus, the helm is not required to counteract that effect; there is, consequently, less obstruction to the ship's way. By reversing either screw the ship may be turned rapidly by *the screws alone* to starboard or port on her centre, or nearly so (as with two sculls in a boat, one backing and the other pulling), and may be steered, going ahead or astern, by these screws, *without any assistance from the helm, in the most accurate manner.* This I have seen accomplished so perfectly, that there can be no doubt of success if properly fitted. The absence of the after stern-post and dead wood, combined with the reduced immersion, will materially facilitate manœuvring, there being considerably less area of resistance, and under any circumstances, whether stationary, at slow or at quick speed, a vessel thus equipped will answer her "screw" instantly, and not only take up, but retain, her position, no matter what the circumstances.

These screws, having their centres much lower than a single screw of the same calculated power, will work uniformly in water of greater density, be far less liable to accident, and, being constantly immersed, will, it is believed, give a result beyond that of a single screw of the usual character. Their size, and the speed at which they are driven, will, of course, be determined by the required speed of the ship. Moreover, both screws and rudders are in a more favourable position for working, being not only constantly immersed, but well removed from the centre of the wake where the water is broken, and there is an eddy or swirl caused by the water closing in from both sides the dead wood, which increases with increased speed.

Rudders.—The rudders are geared together as at I in Plate III., and worked by steam or by a wheel on deck, or in the after part of the engine-room, so that in action the engineers and helmsmen receive orders simultaneously, helm and screws acting together on the instant, helmsmen and steering apparatus being out of reach of shot. I submit that such a combined power of steering would give great advantage to a ship in action, or in narrow seas, over one with one screw, "which would go" against the helm, whichever way her bow "happened to take," whether from the force of wind or current.

Non-Lifting Screws.—In this method of fitting the screws no provision is made for lifting them, it being considered unnecessary, for, in the first place, it is not at all probable that large under-rigged ships would be allowed to depend on sails alone, particularly on special service; and if making a passage the screws could be disconnected or driven by the donkey engines at a speed to overcome friction. I question much if they would make any material difference if not driven; at all events, not much in excess of the resistance now offered by the after stern-post, which must retard very considerably. In this opinion I am supported by the reports of many captains of screw steamers. In smaller vessels and gunboats

these screws might (as we propose to fit them) be readily unshipped and hoisted in over a bill-board on each quarter; the passage could be thus made as a sailing vessel, and the screws easily reshipped when necessary without docking.

Gunboats of very Light Draught.—As the utility of efficient gunboats of very light draught is now beyond all question, I consider this method of constructing them would be attended with many advantages, especially in ascending rivers, where they are constantly liable to ground, or defending our own coast; the keels, as before described, also giving sufficient strength and stability to make a sea voyage; but, unless some very decided alteration takes place in the construction and arrangement of boiler, no considerable reduction can be made in the draught of our gunboats.

Their Boilers.—Some of these vessels have two sets of low-pressure boilers, one reaching nearly to the deck for ordinary purposes, styled "working boilers," which, being exposed to shot, cannot (are not intended) be used in action. The other set, placed lower, but occupying greater fore and aft space, are called "fighting boilers." These, at their best, cannot generate more than sufficient steam to propel the vessels nine knots; whereas, if a suitable form of high-pressure boilers were used, fitted with a surface condenser, they would occupy even less space than the "fighting boilers," do the work more effectually, and leave the space and displacement now occupied by the working boilers for coal or any other purpose. The form of high-pressure boiler, and the method of connecting it with the uptake described hereafter, would be well adapted for this purpose. The engine would also be far lighter and more readily handled than those now in use, especially if fitted with wrought-iron framing.

High-Pressure Steam.—That steam at high pressure with surface condensation must be eventually adopted in war steamers is so universally admitted by engineers, that any remarks I might offer would be superfluous, beyond the fact of Mr. Roberts having constantly urged the adoption of both in his patent, and on many public occasions.

Engines.—As the screws will be driven at a higher speed than a single screw of large diameter, it is proposed to use gearing (direct action, if preferred, being equally applicable), each shaft being driven by two horizontal high pressure engines, K, with surface condensers, P, and multitubular cylindrical boilers, N, the whole of which, including the gearing, will be considerably lower than those in use at present in deep draught ships, and, consequently, less exposed to shot. By this arrangement the huge engines now in vogue would be divided into four smaller ones, lighter, less liable to accident, more readily replaced or repaired, and less costly; duplicate parts may also be carried with facility. The cylinders on the starboard side work the port screw, and *vice versa*, so that a long stroke is obtained. In the ship of 5,000 tons, Plate II., the stroke is 5 feet. By placing the boilers and machinery, as shown in the drawing, the screw shafts L and steam-pipe M are considerably shortened. The framing of the engines is of wrought iron, and therefore lighter than when composed of cast; it is secured to the ship in such a manner as to add to the strength, and, being of wrought iron, is better calculated to

resist concussion should the ship be employed as a ram, or receive the blow of one.

Boilers.—The type of boiler recommended is that proved by long and successful experience to be well adapted for "high pressure," and has been carefully considered and arranged to suit sea-going purposes, every part being strong and easy of access.

It will be observed that they are arranged in two sets, which may be worked singly or otherwise. Mr. D. K. Clark's clever adaptation of the steam jet to promote draught and combustion, entirely preventing smoke, would be specially applicable to these boilers. It assists materially in getting up steam, and, from the absence of smoke, would prove invaluable in a strategic point of view. This invention effects a considerable saving in fuel (an important fact where every ton of coal is of such vital importance), and facilitates the use of all inferior descriptions of fuel.

With this arrangement the furnace of these boilers may be banked up in the most perfect and economical manner, the steam being kept to almost any required pressure, and got up in the least possible time if required suddenly.

These cylindrical boilers may be readily removed for examination or repair, and when clothed with non-conducting material will lose little heat by radiation; should they require extensive repair or removal they may be taken up the hatchways between the funnels, instead of breaking up the deck, as is now the case, in removing the old low-pressure boiler, the hatchways giving light and air, which are so much needed, even in temperate climates.

Funnels.—The arrangement for the "uptake" of the furnaces, O, allows one boiler to be cut off without interruption to the remainder; the cellular casing, O′, around the funnel, will ventilate and lower the temperature of the boiler-room, besides giving additional support and protection to the funnel. Instead of the stokers being between two long rows of furnaces, they stoke from opposite sides, which must necessarily improve their condition. This I consider a very important point, for good stokers are rare; their lot should therefore be improved to the utmost. More depends on good stoking than is generally supposed, and it often happens that what the engineer saves in the engine-room by care and attention during forty-eight hours may be lost in twelve in the stoke-hole by negligence or ignorance.

Coal Bunkers.—The coal bunkers, E, on either side the boiler and engine-rooms, and athwart ships (as shown in the drawings), will add to the security of both, defending them from any shot that may either penetrate the armour-plating or strike below it.

The plan of fitting the coal bunkers, E (as shown in all the drawings), forms an important feature in the cellular system, and adds materially to the longitudinal strength, so specially requisite in light-draught ships, in which "the beam" is of decreased depth.

The coal bunkers in large ships may be filled expeditiously by means of small carriages running on a tramway, the cells being made to communicate with one another, so that the coals can be readily removed if required.

In this cellular arrangement much coal trimming will be dispensed with,

as coal may be taken from any required cell of the bunker without the remainder shifting.

Although the advantages of this principle have been generally admitted, it has been only partially adopted in some instances, but never carried out in its integrity.

Surface Condensers.—The surface condensers are in two sets; as proposed in the specification, they are constructed and arranged in a series of cylinders, either of which may be removed for cleaning or repair without impeding the action of the remainder; they are placed abaft the engines on the incline of the run (as shown), extending to the light water line, the opening for the ingress and egress of water being made in the bottom of the ship. This arrangement, as well as several others connected with the steerage, ventilation, &c., though scarcely inferior in importance to many points mentioned, cannot be clearly shown on so small a scale, but will be cheerfully shown and described on application.

Method of Stepping and Securing Masts.—The method of stepping and securing the masts will add materially to the strength and rigidity of that part of the ship which is now the weakest, viz., the partners. In place of being stepped on the bottom, as is usual, every deck and neighbouring beam bears its portion of the strain, the lower or housed part of the mast being built to the transverse iron bulkheads, as at Q, Plates I. and II., thus forming literally a part of the ship, the wrought-iron knees indicated being strong supports to the deck. The upper part thus built in, projects above the upper deck, the mast stepping over it and resting on a strong iron flange or collar let in to the deck, and firmly bolted together with two rows of bolts or rivets; by this plan a mast might be cut away readily, and the part built into the ship remaining may be used as a step for a wood or jury mast.

Masts and Sails.—I propose to have four masts so disposed that the ship may be manœuvred without head-sails on a bowsprit, as I consider that appurtenance not only superfluous, but ill adapted for war purposes, especially if used as a ram.

The lower masts are of iron; the topmasts and topgallantmasts of wood are in one, the topmast rigging being fitted on a funnel, so that when necessary to strike the masts on steaming against a head wind or in action, they may be lowered down through hatches cut in the deck to receive them (the funnel and rigging being deposited on the lower caps and secured there), and hove up again, without starting the lanyards, by powerful grooved windlasses on the lower deck specially adapted for the purpose.

Should royal-masts be considered necessary, they may be fitted abaft all, as shown in Plate II.

The spars and sails on the two middle or mainmasts are all the same size and form, as are likewise those on the fore and mizen-masts, the only difference being in the height of the lower masts; on them large fore and aft sails may be set, with gaff-topsails over, but I should infinitely prefer staysails, which, if properly cut and set, are better and handier sails aloft.

Labour-saving Machinery.—As it is of the utmost importance that every contrivance should be resorted to that may reduce weight, economise space, and save labour, I advocate a more extended use of simple mecha-

nical contrivances than has heretofore been the custom, and if the reduction in the crews that has been spoken of is carried out in consequence of decreased armament, "labour-saving machinery" must be be adopted; hence, the windlass applied for striking and fidding topmast.

Windlass.—As another means of effecting this, I recommend the windlass shown in Plate III., W, which may be worked by hand or steam, the principle of which has been amply tested in a variety of shapes.

This windlass may be readily applied as a substitute for one or both the capstans now in use. It is calculated to prevent the accidents so often occurring by the capstan throwing the men over the bars. When once brought to the windlass, *all handling the chain is done away with;* it being purchase, bitts, and stoppers combined; bitting, unbitting, and ranging the chain, are entirely dispensed with—a very obvious advantage in using the heavy chains now necessary in large-class ships. All jerks and strains now experienced in veering, letting go, and riding at an anchor, are obviated, and the cable is ready for veering, letting go, or heaving in, at a moment's notice (messengers, nippers, and stoppers being dispensed with), the chain being under perfect control of the powerful brake attached to it. It occupies far less space than the present capstan with the bars shipped, and may be used for any purpose on board, being not only a powerful steady purchase for lifting heavy weights, such as guns, boilers, &c., but lowers them steadily without jerking, as must be the case in lowering round a capstan, &c., where surging is necessary. It is also well adapted for sheer falls, and all other purposes of a similar character, where great steadiness and regularity in hoisting and lowering are required, and may work any length of chain without riding turns. The advantage such a windlass will give in veering in a gale over the present inefficient and uncertain mode is too obvious to need comment.

Light-Draught Coast Defence Ships.—Descriptions of plans and sections of a light-draught coast defence ship, of about 2,300 tons, length 240 feet, breadth 45 feet, draught 15 feet, mounting 14 guns, 8 feet 6 inches above the water.*

No. 1 is a general exterior view, showing a proposed method of protecting the guns by inclined armour-plated sides, rounded from the deck upwards, terminating in a rounded platform or deck; the top sides forward and aft being fitted to lower when bow or stern guns are used.

2. Deck plan, showing a method of giving ventilation and light, and relieving the gun-deck from smoke by a strong iron grating, R, in which are hatchways for giving access to the deck, for boarding or repelling boarders.

   R R are other hatchways, similarly fitted for ventilation and access to other parts of the ship.

3. Longitudinal section, showing internal arrangements.

   T. Bread and dry provision room.
   K. Engine room.
   E. Athwart ship coal bunkers.

* This model was designed by us to meet conditions suggested by Rear-Admiral George Elliot, and submitted by him to the Admiralty and War-Office, in June, 1861.

N. High-pressure cylindrical boiler, with method of fitting the uptake to funnel, and the cellular casing round the funnel to give ventilation in the boiler room—same arrangement round masts to ventilate between decks. The funnel is telescopic; when run down projects only three feet above the deck in action, which is protected, the draught being given by the apparatus described, which also prevents smoke.

U. The magazine.

V. Chain locker.

W. Windlass, described previously.

X. Form of stem for receiving the prow of ram, and method of strengthening the bows to resist the shock, being a series of short decks or breast hooks.

4. Arrangement of longitudinal bulkheads, forming cellular girder, with the side applied as coal bunkers, water tanks, and other purposes.
5. Stern view, showing propellers, and three stern chase guns, with gunwale lowered on starboard side.
6. Section in engine room, showing proposed arrangement of engines, K; coal bunker, E; with cellular bottom and keels, C, D.

This vessel is intended for the defence of harbours, or to cross the Channel if required, being quite capable of taking the sea, and may be rigged either as a schooner or polacca. She is fitted to act as a ram, and, from her great longitudinal strength, imparted by the peculiar mode of construction described, is, I conceive, specially adapted for that purpose, as also from the fact of the two screws giving her the power of turning in her own length, and, being steered by them, going ahead or astern without assistance from the rudders; in fact, under steam the rudders are unnecessary.

Armament.—I propose to arm this vessel with 14 guns, two of which are to be of very heavy calibre, one forward and the other aft, being bow and stern chasers, firing in a line with the keel, as shown in the drawing. The guns on either side may be fired in the same direction, or as broadside guns, by shifting them, there being spare ports for the purpose. Thus, three guns can be brought into action, whether chasing or retiring, and six on the broadside.

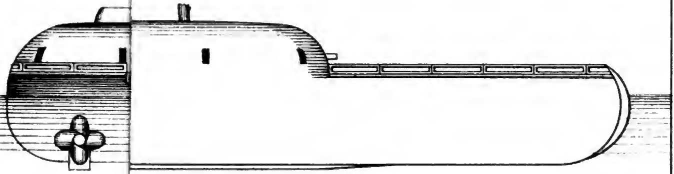
The cellular keel and bottom will allow sufficient water to be admitted to immerse the ship from a foot to eighteen inches; thus one foot of armour-plating might be dispensed with, and a smaller mark displayed to the enemy.

This plan of defending the guns, in addition to the advantage of having a battery of three guns forward and aft, will reduce the weight of hull and armour-plates.

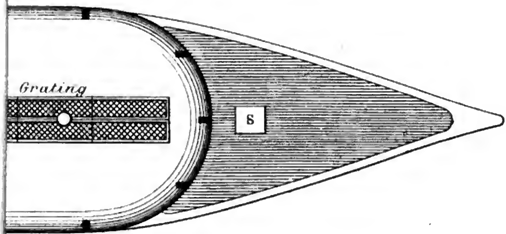
Smaller vessels on this plan, drawing 10 feet of water, and mounting four guns, might be very effectively employed in rivers, small harbours, and creeks, they being capable of grounding without injury, and when grounded being upright. Moreover, such a shield vessel, having the power of turning as described, would become "the turntable," and thus bringing the guns into action as required, an incessant fire might be kept up. All attempt at accommodation in the usual acceptation of the term should be abandoned in such vessels, they not being required to go to sea.

. 14 GUNS.

Fig

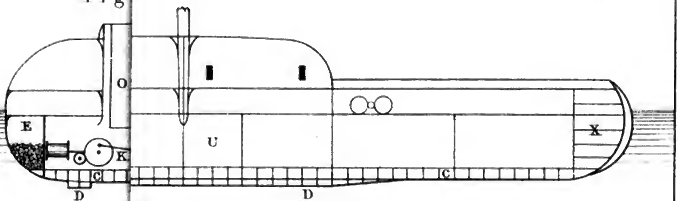


Stern



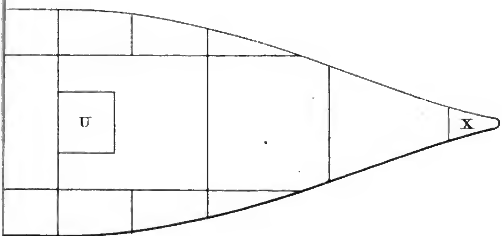
k.

Fig



n.

Transverse



E. and Commander T.E.Symonds R.N

J.R.Jobbins

Duplicate Arrangements.—In conclusion, I beg to call attention to the fact that in all the arrangements I have described there is a *duplicate of every principal part*, so that in the event of one breaking down, the ship may never be totally disabled, except under very extraordinary circumstances. This will, I believe, be admitted by sailors (and it is to them more especially I address myself) to materially enhance the efficiency of a steamship of war of whatever description.

And I may add that the models and plans I have exhibited and described are not suggested by the results of recent experiment, but that they were for the most part prepared long previous to the now well-known proportions of iron-cased ships being published. Never having had access to the weights and quantities required for ships of that class, we may have possibly erred in some of the proportions, but they may be readily altered to suit special cases, the principles of construction and the method of steering and manœuvring being applicable to all.

Models of these vessels may be seen at the Naval Department of the International Exhibition, Class 12, and at 10, Adam Street, Adelphi.

Mr. Samuda: I have no remarks to make in general upon this paper. It is new to me as I hear it. A few things I feel certainly bound to say with regard to it. The description of rudder does not come before me as new. I have had through my hands vessels with similar rudders to those, and I am bound to say they were not at all satisfactory.

The Chairman: Was it from their position? Before or behind the screw?

Mr. Samuda: They did not act well. I think it is not at all impossible that the position relatively to the screw may have acted very much to their disadvantage. Instead of getting the benefit of the water washing up to the rudders, the water came to them before they had the benefit of being pushed further by the screw. Certainly, the result of steering equally well forward and aft, as contemplated in this paper, was not at all realised in these vessels. My first acquaintance with these vessels was this: they were brought to me to have their rudders taken out, because they were not found suitable. We took them out, and put in ordinary rudders behind the stern-post. I do not condemn them, I merely state the fact as it occurred. With regard to the screw itself, I would ask whether the inventors have had sufficient experience in that length of blade, which they have got there, to find that they get as good a mechanical result as we do in those proportions which experience has shown us, at least with our present knowledge, to be the best? We find that if we depart very much from the proportions which have been arrived at by practice, that the effect is something extraordinarily bad. Just to give an illustration. Assuming that one-sixth of the length or pitch of the screw is considered a very good proportion in a large sized screw, in a smaller sized screw one-eighth is found to be so. I recollect a circumstance of having no less than five vessels built all off precisely the same lines, and of having a variation to the extent of two of them being one-eighth of the length, which produced a very good result to the ship. One of them, under the impression that a much better result was going to be obtained, particularly in heavy weather, as it was stated, by giving greater surface to the screw, having been subsequently made something over one-sixth, we lost a knot and a half out of the vessel; the same engines, made by the same man, the ship's form precisely the same; the lines in every respect the same. Cutting the screw brought the vessel back again to exactly the same condition as her sister vessels. Therefore this is a thing which ought to be well considered before it is put forward. Then, all our experience goes to the absolute necessity of doing away with the gearing. Gearing is a thing of past times. It was introduced, and it was used very extensively, when screws were first put forward; for the simple reason that people were

not prepared to make engines go, not prepared to think that they could go at the speed at which it has since been found it is not only advisable to drive them, but at which they can be driven and kept in ordinary and fair repair. But with the expense of maintaining gear, the noise accompanying it, the uncertainty of breaking the teeth, and all these sort of things, certainly it is looked upon by all mechanics as having been a very fortunate day for screws when a sufficient amount of perfection in the manufacture of engines has been arrived at to enable gearing altogether to be done away with. Therefore those points do not appear to me to be walking in the direction of improvements. How far the other points of the invention may bear, such as the double keel, I do not profess to know anything about; I have not had experience of them. With respect to double screws, I must say that my experience is very unfavourable to them. I was always led to suppose that in shallow draught of water double screws performed very much more than single screws; but within the last two years I have made a number of vessels for the Spanish Government, fitted with double screws, but we did not find the increased speed from them which we had got under similar circumstances with single screws. We found this disadvantage, that when we were attempting to turn with double screws we literally stopped the way of the vessel. Putting the helm over, so completely blocked the passage of the water from the screw opposite to which the rudder was turned, that we brought the vessel up from nine knots an hour to something like three. It was exactly the same as if that screw was working at mooring, and a corresponding disadvantageous result was obtained on the vessel. Altogether I came to the conclusion that double screws had nothing like the advantage of a single screw of larger diameter, placed in the dead wood of the vessel. Even though a portion of that screw is out of the water, yet you will perceive that the surface of the single screw below the water is very much in excess of that which the two screws give together when wholly submerged. I merely mention these things to the inventors for their consideration, that they may turn their attention to them and see how far they may be able to realise all the expectations which they have put before us.

Captain Collinson, R.N., C.B.: With respect to the double screws, I may say I was in Canada last year, and I had the opportunity of seeing a great many propellers with double screws. On conversing with the people, they came to the same conclusion that Mr. Samuda has. They said they were going to put in no more double screws; they had tried them both at the sides and at the stern, and in neither case did they answer so well as the single screw.

Captain Symonds: In answer to what Mr. Samuda has said about gearing, I would say that Mr. Roberts prefers that mode of applying the power; because in driving small screws to make them equal to larger screws, of course they will have to be driven at considerably higher speed; and knowing that there has been an objection to driving a piston at a very high speed, he introduces the gearing to relieve the engine. I may add that it is quite as possible to drive direct in this case as it is in the others. But with respect to the double screws, and to what he said about the rudder, I apprehend that the rudder he refers to was a rudder placed in the old style; and that the two screws he was speaking of were placed one on either side the dead wood, the rudder being between them.

Mr. Samuda: Yes.

Captain Symonds: Exactly so; and in the course of my observations I mentioned that that was one of the objections that had been raised to two screws, that there was not sufficient space, with the dead wood existing, to leave the screw sufficient space to work; also that the water was so confined by the dead wood that it was almost impossible to use them effectively. It is for that reason that we do away with the dead wood entirely. Now, I beg to submit that these two screws are under very different conditions to the two screws which Mr. Samuda spoke of, with the dead wood running between them, and the rudder abaft it. I can quite imagine that if there was the dead wood running down between, and the rudder being immediately abaft them, it would, of course, whenever the rudder was shoved over, have exactly the effect on the screws he has described. But in this case the rudders are below and before the screws, and, as I mentioned, they both act independently of one another—the water coming as fairly to one as to the other—so that I do not agree with him, that because they did not answer in the case he mentioned, they should not answer in this. I do not think the conditions are at all the same.

The Chairman: Have you got any account of experiments that have been tried?

Captain Symonds: No, there have been no experiments with these vessels. Experiments which I have seen with a vessel with screws somewhat similar to these were certainly very satisfactory. She was a very light-draught vessel, as I have described, with a long

shallow rudder. They never appeared to interfere with each other; they never touched one another; and she readily turned round in her own length without moving the rudder.

Mr. SAMUDA: Where was that rudder placed?

Captain SYMONDS: That rudder was placed in the ordinary manner; and, certainly, the steering was most perfect with the screws alone, as I described it. However, I can quite understand what Mr. Samuda's objection is to the two screws, generally, with the dead wood between them. This is a totally different case, and also with the rudder. In the rudder that Mr. Samuda spoke of as being altered, I am quite aware that that is the case. I believe he is not the only person who has altered a vessel of that description; but I think Mr. Samuda will say that the rudder was not placed as this is.

Mr. SAMUDA: I think so.

Captain SYMONDS: Not in the same position with the screw.

Mr. SAMUDA: Precisely.

Captain SYMONDS: Was it, with regard to the screw?

Mr. SAMUDA: Precisely.

Captain SYMONDS: Under it, or before it?

Mr. SAMUDA: Before it, not under it; yours is not under it.

The CHAIRMAN: The two rudders?

Mr. SAMUDA: No; there was one rudder and one screw. But I must be understood as not wishing at all to say anything in derogation of the invention. I am only calling attention to these points to prevent mistakes being made, if by experience they can be guarded against. What I intended to convey was: first, that the rudder, placed precisely in a similar position to the screw as one of those you represent, has come before me in one instance in a vessel with the screw and the rudder, and has been found quite inefficient. It was not only in one instance, but in two. There were two vessels brought to me to be altered, because they would not steer. The pilots had taken a great deal of pains, and one a great deal of expense, before they were brought to me. Therefore, I wanted to convey to you, so far as my experience went, that that portion of the invention was bad; that is to say, not likely to be successful. Therefore, if that portion was obliged to be abandoned, the other that would be left to you, would be to put the rudder in the ordinary place, and with two screws my experience shows that to that extent it was not satisfactory.

Captain SYMONDS: I still maintain that the rudder in the case mentioned not answering does not condemn this; because, in the first place, that was a single rudder in the centre, and these two are at the side, and there are, therefore, two surfaces acting instead of one. I believe the reason why one or two of those vessels which Mr. Samuda mentioned did not steer, was because they had not sufficient rudder to steer with. That is what I have generally understood. However, I am obliged to you for mentioning the matter; of course, it will make one look more closely to the subject. At the same time I hope before long to be able to show you a vessel which will probably do away with the impression which you appear to have.

The CHAIRMAN: The subject is very important. We were very much at sea when the screw was first introduced. With a little change in the pitch of the screw there is an extraordinary difference of result, and we are not able to explain why it is. It certainly is very important with long ships that they should be able to turn with facility; if it could be arrived at, one would desire to see it very much. No doubt, it is puzzling to conceive that two screws will give so great a result as one with a very much larger diameter. I do not understand it myself; yet, seeing how our preconceived opinions are overturned every day, one cannot undertake to say that it will not do so. Many persons object to the rudder being so far forward, and they think the effect is not so great. I have long thought the very reverse of that. I think a rudder placed so far at the extremity, so long a distance from the turning point, is injurious. I believe the further aft the centre of gravity is towards the rudder, the more quickly the vessel turns; so, in bringing the rudder towards the centre of gravity, the same thing would happen. I do not think it is from the position of the rudder—I mean relatively to the centre of gravity—that the defective steerage would arise; I think it would be much more likely to arise from the screw. It does not, as in ordinary screw vessels, come upon the rudder to increase and intensify the action of the rudder. Therefore, I think the position of the rudder there would not be so good as in an ordinary screw vessel by a large amount. Of course, the action of the keel is very useful in retarding the rolling motion; but still, at the same time, I think it is rather the introduction of another evil, in some respects, to reduce an existing evil. Such, for

instance, as introducing the keel to stop the rolling in the "Warrior," putting bilge-pieces. These are mere makeshifts, and ought not to be necessary. I believe if we were to experiment and investigate we should be able to build ships without having recourse to these makeshifts to improve their qualities afterwards. However, I think we are very much indebted to Captain Symonds for having brought forward this subject, and I am sure you will allow me to return our thanks to him.

Mr. ROBERTS: With reference to Mr. Samuda's remarks about the screw, let me say this screw begins at a favourable angle to propel (45 degrees), on account of the largeness of the boss. The area of one of these blades is 15 feet; the whole of them would be 60 feet; and as there are two screws, they give together a surface of 120 feet. Whereas a propeller, for the same purpose, has not above 80 or 90 feet. With regard to gearing, if gearing be properly made, it will last indefinitely long; it only depends on the make. But if you do not like gearing, you may use friction wheels; they will not make much noise.

Mr. SAMUDA: They have been found very objectionable indeed. A little oil pouring on them will spoil them altogether.

Mr. ROBERTS: There are many mills in England that have gone many years with them.

Mr. SAMUDA: They do not put so much power through them as they do in the screws.

Mr. ROBERTS: However, gearing, if well made, will last indefinitely long; I say I can make a pair that would certainly go for forty years.

Captain SYMONDS: Those in the "Great Britain," for instance.

The CHAIRMAN: I think you should observe that the resistance which this offers is only equal to the diameter of the cone. It is a question of introducing a multiplicity of blades. You increase your surface by increasing your blades; but that does not increase the resistance to the amount given by the one screw of greater diameter.

Captain SELWYN, R.N.: I should like to say a few words to Captain Symonds upon this subject. I have found, on studying attentively the action of screws as shown in water, and all the old conditions under which Mr. Napier and others have put in two or more screws, that they have generally failed, simply because the ordinary view of the action of the screw in water is that it acts against and throws off a column or cylinder of water. Now, what the screw really does, is to throw off, and, therefore, act against a truncated cone of water, partly caused by the centrifugal action set up by the revolution of the screw. There is, therefore, a compound force producing, not a cylinder but a peculiarly shaped truncated cone. Now, under these conditions, you cannot put in two screws parallel and close to each other with good effect; the two cones crossing each other invariably and seriously deduct from the resistance of the water. In one of the floating batteries, three of these small screws were put in, one in the centre in the usual place, the other two under the counters, with parallel shafts. The result was not good. It was found afterwards, on lifting out the two side screws and leaving the centre one, that the same speed was obtained as with the three; but that was only from the cause I have before pointed out. Had those two outside screws been placed widely apart, or at divergent angles, you would then have had the full effect of all the screws, minus the deduction (in the case of the divergent ones), due to the parallelogram of forces, as every one knows who has studied that theory. But of course no one will ever attempt to prove that two one-inch pipes are equal to one two-inch pipe, or that two screws of ten feet diameter can ever be equal to one screw of twenty feet diameter. It would be an utter fallacy. The area of push, from which you derive your motive power, would be, of course, very much lessened. I need not say that my impression is, that if you get two screws of the full size due to the draught of water, nobody will be inclined to contest that you get a greatly increased efficiency, and I believe that it is not at all impossible, if they are as widely separated as in these models, to drive them at the ordinary speed attained with horizontal engines, without gearing and with excellent effect.

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LECTURES.

Friday, February 7th, 1862.

COLONEL R. WILBRAHAM, C.B., Governor, General Hospital, Woolwich, in the Chair.

GERMAN CAMPAIGNS OF GUSTAVUS ADOLPHUS.

By BRIDGES C. HOOKE, Esq.

THE military glory of Austria and the Roman Catholic confederacy known as the League had reached its highest point in the twelfth year of the Thirty Years' War. The King of Denmark, defeated at Lütter, and driven to his islands by the combined operations of Tilly and Wallenstein, had been forced to sacrifice his political and religious sympathies to the misery of his subjects and the exhaustion of his resources. Mansfeld, a thorough soldier of fortune, had vainly raised three successive armies in defence of the Protestant cause, and had campaigned with them in Bohemia, Westphalia, Saxony, and Silesia, with a celerity of movement that was equalled only by the ease with which he repaired his losses in the field. Antæus-like, he seemed to rise stronger from every overthrow. Pay was unknown in his armies, but its place was fully supplied by an unlimited licence to plunder. It is of course impossible for any army living, as it were, from hand to mouth under conditions such as these, and never dreaming of forming magazines, to secure a base of operations or to conduct a regular campaign. The exhaustion of the resources of the surrounding country of itself creates a necessity for a change of plan, and for the tranference of the locality of hostilities to lands that have hitherto escaped the grasp of the marauder. As a rule, such a desultory system of warfare must eventually succumb to the more elaborate operations of regular troops. It reflects no small glory on Mansfeld's military capacity, that through many years of warfare, and till the defeat of the King of Denmark decided the event of the contest in Northern Germany, he continued to baffle the skill and thwart the plans of the ablest generals of Austria and the League. Even after the intelligence of the crowning disaster of Lütter, when a less hardy spirit would have retired from the field, he formed the idea of carrying his arms into the very heart of

Austria; and, breaking through the dense circle of his opponents, evading the hot pursuit of Wallenstein, and suddenly appearing in Transylvania, he engaged the sympathies of Bethlem Gabor in favour of a broken army and a ruined cause. But the Prince of Transylvania, alarmed at the rapid approach of Wallenstein, concluded a peace as precipitately as he had appealed to arms, and Mansfeld, disbanding his army, retired to Venice, where he soon died of a broken heart. In the same year the deaths of Christian of Brunswick Lüneburg and the Duke of Saxe Weimar deprived the Protestant cause of its last supporters, and left it exposed to the full power of Austria, aided by the military talents of Tilly and Wallenstein, by the active co-operation of the League, and the inexhaustible resources of the Spanish empire.

Few men have left behind them a more terrible reputation than John of Tzerkläs, Count of Tilly, a companion of the order of Jesuits, and generalissimo of the army of the League. The Church of Rome, as indeed every other church, has in all times of its existence commanded the service of a body of enthusiasts, prepared, nay anxious, to sacrifice every feeling of humanity to their passionate ardour for the supremacy of their faith. And never had Rome a more devoted son than Tilly. Wine, wealth, and woman's love, the desire of knowledge and the thirst of fame, find responsive chords in almost every breast. But Tilly's heart, dead to every softer mood, insensible to every loftier inspiration, was swayed but by a single influence—his passionate ardour for the victory of his creed. Even his constant success in the field seemed to him less a result of his military ability than an evidence of the favour with which the saints regarded his feeble efforts; and to his mind the sacrifice of a heretic, the destruction of a heretic city, was a deed for which his ecclesiastical superiors might of their grace demand admission for his soul into the mansions of the blest. Great soldiers have sprung from temperaments of such a mould; and it seemed at one time as if few or none of these would be able to contest the crown of pre-eminence with Tilly. Yet, as it often happens with those whose life lies on the verge of two widely different eras, it was his hard fate by the onward course of events to lose in one day the glories of seven victorious fields, to throw away a hundred chances that Fortune offered with a lavish hand, to heap mistake on mistake, to be hurried against his will into battle by the imperious temper of a subordinate, and to be ignominiously routed by an enemy of scarcely half his strength. So inexplicable seemed his overthrow, that men ascribed it to the direct intervention of a higher power, that, roused to vengeance by the cry of innocent blood, had resolved to suspend the stroke of death till the sinner had drunk the cup of degradation to the very dregs.

In the cold, ruthless ferocity of their dispositions, there was but little difference between Tilly and Wallenstein. In other respects they varied as the enthusiast from the politician. Tilly, trusting in the favour of the saints, flew like a tiger full at the face of his foe—Wallenstein encircled him with the folds of a boa constrictor. The object of Tilly's attack might brave his fury again and again; but the grasp of Wallenstein was death. Tilly fought for his faith, Wallenstein for his own ambitious views—Tilly for an immortal crown, Wallenstein for an earthly sceptre. So, while in one campaign Wallenstein swept all before him with the sweep of a tornado, in another he let the war rage as it would. Entreaty, taunt,

and menace failed to draw him from the shelter of his camp. None could unravel the tangled skein of intrigue that he wove in the dark depths of his inscrutable mind. Even the assassin's dagger failed to solve the Gordian knot, and left the name at which the world grew pale to be the riddle of the historian. The intellectual powers of a mere child are amply sufficient to discriminate the essential difference between patriotism and treason; but the subtlest minds have been unable to determine whether Wallenstein was a patriot or a traitor.

Field-Marshal Count Pappenheim was but little inferior to the two generals whose fame has eclipsed his own. By a rare combination of talents he united the cunning of an Ulysses to the impetuous valour of a Mezentius. Men pointed him out in the streets as one marked out by fate for a warrior's life and a warrior's death, for at his birth a mark resembling two crossed swords was to be seen clearly traced out on his brow. Time in its onward course had all but obliterated the ominous blazon, but in the fury of the charge and the crisis of the battle it ever flashed out like a fiery star. His body, it was said, was gashed and seamed by full a hundred wounds. His fate was foretold by nature's self, yet he still rode as gallantly and blithely to battle as to bridal. Born in the same year, he fell on the same day, as Gustavus Adolphus, full of fame, though young in years, the sword of Austria and the Ajax of the war.

The armies who marched under the banners of these great chiefs bore characters as strongly marked as were those of the leaders whom they served. Every one is familiar with the portraiture of the gallant soldado of the seventeenth century, his low-crowned hat and drooping plume, buff coat, gorget and cuirass, scarf, tassettes and bandolier, a costume so noble and graceful that it seemed designed by the very genius of war for his votaries. The camps of Wallenstein and Tilly swarmed with high-mettled cavaliers, gay, careless, and defiant of death, sudden in quarrel, quick of eye, and open of hand. Vienna sent forth her gay and thoughtless sons; the Walloon lent his ponderous strength of horse and man; the German the dogged determination of his race; the Scot a valour lofty and self-reliant, tameless as the billows that burst on his own rugged shore, and stubborn as the cliffs that fling them from their giant breasts; and the Spaniard a chivalry, discipline, and renown tested by upwards of a century of warfare in the New World that his enterprise had discovered, and in the Old, which his arms had all but subjugated. Croat, Sclave, and Magyar, wild horsemen, whose trumpets had sounded alternately in the van of the Crescent and the Cross; the needy adventurer, the reckless criminal; all who owned a stout heart and a good sword, were welcome auxiliaries to the armies of Austria and the League.

Mansfeld had introduced the system of making war support war. Wallenstein carried out this principle to its fullest extent. It was his maxim that 50,000 men would live where 20,000 would starve. The stronger his force the greater its opportunities of plunder. A prince or city might bid defiance to a small body of men, but must buy off an overwhelming army. As long, then, as there were petty princes and rich and peaceful cities in Germany, so long would there be a perpetual flow of wealth to the pockets of the soldiery.

The camp was a strange and terrible sight. "Where Wallenstein's

horse treads there grows no grass," was the saying of the time. A howling wilderness piled with festering corpses, and bright with the light of blazing villages, spread for miles round his quarters. It was from the vocabulary of his camp that the word plunder found its way into our language. Another word, "marauder," is a corruption of the name of Merodé, one of Wallenstein's favourite officers. The camp was one wild scene of revel. The officers flaunted in scarlet and gold; many a well-lined purse fell to the private's share. Costly wines were broached, woman gave her smiles, and the gambler plied his trade. But when the ordinary supplies of booty failed the soldiers deserted by battalions to the standards of some more prosperous leader. The discipline, though fitful, was of the sternest kind. The gallows was a standing institution. Regiments were decimated and men strung up by the score.

In the day of battle the army was drawn up in huge unwieldy battalions ten deep, and from two to three thousand strong. Each regiment was divided into ten companies, and each company contained from two to three hundred men, one half of whom were armed with pikes, and the rest with matchlocks. Another and still more preposterous formation was sometimes adopted by the Imperial armies, and is reported, though, to my mind, hardly on sufficient grounds, to have been used by Wallenstein at Lützen. A body of 5,000 infantry was divided into 50 half companies, each 100 strong, five such half companies of pikemen, with a front of ten men each, and of course of an equal depth, being then taken as a base. A solid square was erected on this base (as represented in the diagram on Plate I.), showing a face of 50 men on each side, and a depth of the same number, and 2,400 musketeers were now ranged as a border, ten men deep, round these. The remaining 100 musketeers were then placed at the corners in little solid squares of 25 each, so that the whole arrangement looked like a huge square castle with little turrets at the angles. Of course the immediate result of this stupid arrangement was to render the pikes of the centre perfectly useless, and to prevent all but the first, or perhaps the first and second, lines of musketeers from firing a shot. As may easily be conceived, hostile artillery ploughed deep lanes through such an unwieldy mass, and unevenness of ground soon broke up the regularity of the formation. Even in the ordinary ten-deep line of battle more than half of the soldiers took no appreciable part in the engagement; but in the arrangement I have just described it is probable that not one soldier in twelve ever had a chance of using his weapons. It is true that the system of the phalanx had reached its highest point of perfection in the armies of the Empire, and that the Imperialists had hitherto been almost uniformly successful in every campaign. As yet, however, battles had been confined to the encounters of opposing phalanxes, and legion and phalanx had yet to meet in the shock of arms, and establish in a fairly fought field a decision that should be valid, not for the moment only, but to the end of time.

Wallenstein was dismissed the Imperial service in consequence of the personal animosity borne him by Maximilian, Elector of Bavaria, and head of the League, at the very moment when his services were most necessary, and the command of the combined armies had been committed to Tilly. The soldiers of Wallenstein's old army deserted by tens of thousands. In 1628 they alone had marched against Stralsund 60,000 strong.

When Gustavus Adolphus landed in Pomerania in June, 1630, the whole force of the two confederate armies could scarcely have shown so formidable a muster. The king's own army, numbering at the outset about 15,000 combatants, found itself opposed to a force of about equal strength. Gustavus's first object was to secure an effective base of operations. He was master, indeed, of the sea from the beginning, but, in order to advance, it became necessary to force the Duke of Pomerania into an alliance. By this measure he gained the assistance of a body of troops who afterwards, under the name of the White Brigade, yielded to none in their valour and their fidelity to their leader, and of several fortified posts from which he was able to extend his operations towards the interior. Before the conclusion of the year he had chased the Imperialists out of the dukedom. Tilly and Pappenheim, whose troops were quartered in Westphalia, had made no aggressive movement. The old soldiers of Wallenstein flocked to the king's camp by hundreds at a time. Important reinforcements reached him from Sweden and Scotland. He had concluded a treaty of alliance with France, and was prepared to open the campaign with an army of 30,000 men.

The Swedish regiments of infantry consisted, exclusive of officers, of 1008 or 1152 men each, divided into eight companies each of 126 or 144 men. Of the entire number two-thirds were musketeers and one-third pikemen. They were usually drawn up six deep, pikemen in the centre, and musketeers on the flanks. To resist infantry, the musketeers advanced till their fourth rank became a continuation of the first line of pikes, and then poured in their fire. To resist a cavalry charge the three first lines of musketeers fell back on the three last, thus leaving the pikemen in their turn three ranks in advance. The larger portion of the musketeers were still armed with matchlocks, the flintlock, then a modern invention, not having come into general use at the commencement of the king's enterprise, and at the same period, and until Gustavus reduced their weight, both weapons still required the assistance of the rest. The Swedish pikemen still wore helmet, breast-plate, and tassette, but the king had already deprived the musketeers of a weight of accoutrements which was at once an inefficient protection against a bullet, and an impediment to their activity in the field. In the German armies the musketeers still carried the bandolier, a belt stretching from the left shoulder to the right hip, and garnished in front with eleven little cylinders, ten of which contained a charge each of powder, and the eleventh a supply of the same material for priming, and to the extremity over the hip were attached a powder-horn and a box of bullets. The match was suspended to the little finger of the left hand, and on the march the matchlock was carried over the right shoulder and the rest in the left hand. The king superseded the bandolier and its appendages by the introduction of the cartouche box, filled, as at present, with cartridges, and did away with the rest by gradually diminishing the weight of the piece. At the same time he added to the efficiency of the pike by reducing it from its cumbrous length of sixteen feet to eleven.

Each regiment consisted of two battalions, each commanded by a lieutenant-colonel. The colonel in chief, as in our army of the present day, was almost always a general officer. A captain, lieutenant, and ensign had the charge of each company, and had twenty-four non-com-

missioned officers under them. It was, among other things, the captain's duty always to keep the company at its full complement, and for this purpose he received, over and above his own stipend, a private's pay for every ten men actually borne on the strength. To attach the soldiers still more to the regimental colours, the ensign who had them in charge at the moment was prohibited from inflicting punishment upon any soldier, and in case of certain minor offences was allowed the privilege of publicly asking remission of the sentence, and it was the general policy of officers commanding regiments to comply with his request.

The cavalry was formed into regiments 500 or 600 strong, each divided into eight squadrons or sixteen demi-squadrons. In this branch of the service Gustavus was generally numerically inferior to his opponents. It therefore became his practice to make up for this deficiency by posting small bodies of musketeers between the different regiments of horse. But the introduction of a newer and bolder system of tactics made his cavalry formidable in a degree that was out of all proportion to its numbers. It was the manner of the Imperial cavalry to ride up close to a hostile body of infantry, pick off as many of the first line as possible with their pistols, and then charge if they could effect a practicable breach in the line, if not, to gallop to the rear and reload, while the second, third, and remaining ranks continued the attack in the same fashion. The orders to the Swedish cavalry were, that the first line should discharge their pistols right and left as soon as they could discern the whites of their enemies' eyes, taking care, at the same time, not to slacken their speed. The whole body was then to fling itself among the enemy, the rear ranks reserving their fire for close quarters. The success of this new system had the effect of restoring the character of the cavalry from the position of undue depression into which they had fallen in consequence of the collapse of the feudal system and the brilliant victories of the infantry of Switzerland and Spain. It may also be mentioned here, before turning to a different head, that Gustavus was the first after the Romans to give its due importance to military engineering. His men were all trained to the shovel and the pick. He constructed many fortified camps while in Germany; in only one was he attacked. In this case he beat off a superior force in two separate assaults. Every one of the others was pronounced by his enemies to be absolutely impregnable.

The artillery of the Imperialists was of the same unwieldy character as their discipline. By its weight and cumbrousness it was a constant clog and impediment on the line of march, and it was next to impossible to move it from place to place on the day of battle. The greater portion of Tilly's guns were 24-pounders, though 48-pounders were frequently used, and a 24-pounder required twenty horses for its own transport and twelve more for its attendant waggons. Even a 16-pounder weighed between forty and fifty hundred weight, a 2-pounder weighed ten hundred weight, was five feet and a-half in height, and required four horses. In this branch also the use of cartridges was unknown. When a gun was brought into action, a barrel of balls was placed on one side and one of powder on the other. The heads of both having been knocked off, the master gunner on one side poured in a shovel full of powder, and his companion opposite rammed a ball on top of it. Under these circumstances, artillery practice in the armies of Tilly and Wallenstein would hardly have passed muster

at Woolwich. Gustavus applied himself zealously to remedy the defects I have just enumerated. In the first place he introduced the use of the cartridge into the artillery as well as the infantry. Next, by a singular combination of brass, leather, iron, and cord, he constructed a weapon on which was bestowed the name of leather cannon, so light that it could easily be moved from place to place by one horse or a couple of men. This instrument did good service in the field, especially at Leipsic, but, as it became useless after ten or twelve discharges, it was gradually superseded by the improvements effected in the old system. The Marquis of Hamilton determined, after a series of experiments, that the weight of the guns actually in use might be materially lessened without impairing their efficiency, and Gustavus immediately put the result of the marquis's investigations into practice, and with so much success, that, while the Austrian 2-pounder, as I have stated above, weighed ten hundred weight, and required four horses, the Swedish 4-pounder weighed only six hundred and twenty-five pounds, and was moved from place to place by half the number of horses required by the other weapon. He also introduced the practice of mingling light with heavy artillery. In case of an attack, the lighter pieces remained behind to impede pursuit, while the heavy guns were drawn out of the reach of danger.

The efficiency of the Swedish artillery was well supported by the rapidity of the fire of the musketeers in the same army. Among the Imperialists the musketeers were drawn up so as to form one wing of a regiment, the other wing being composed of pikemen. Therefore, when a regiment was at full strength, its complement of musketeers amounted to 1500. Of these 150 stood in each rank. When the first rank had delivered its fire, it ran off right and left along the whole face of the wing, and passed nine files before it drew up again as a tenth rank to reload. Thus each rank had to run round 1350 of its comrades. With the Swedes the pikemen stood close, but each rank of musketeers was divided into squads of 4 or 5, each superintended by a non-commissioned officer, and each separated from the next squad by an interval of two or three feet. Thus the musketeer, after discharging his piece, had to pass only 3 or 4 others in rank and five only in file. Under these circumstances the fire of the Swedes was of course infinitely more formidable than that of their opponents.

It will be seen at a glance that the effect of all these reforms in the art of war was to substitute lightness and rapidity for weight and solidity; the legion for the phalanx; the mobility of the detachment for the inertia of the mass. Amongst the Swedes the unit of discipline was the company, among the Imperialists the regiment. But in battle the rout of a single company would be a matter of but trifling importance in all probability, while the overthrow of a whole regiment, 2000 or 3000 strong, would make a fearful gap in the line. Nor had the German commanders in general any means of repairing such a calamity, for it was their constant practice in following the order of the phalanx to draw up their armies in one long line without any reserve. The king, on the other hand, always arranged his troops in two lines, with a reserve to each. In the battle of Leipsic a large body of cavalry attempted to outflank and get into the rear of the king's first line. This attempt was at once frustrated by part of the second line and the reserves of the first, and the assailants were

driven off the field. Conversely the appearance of the king in the flank and rear of Tilly's forces in the same battle led to the capture of the whole of the hostile artillery, and to the first great victory gained by the Swedes on German soil. It is most probable that Wallenstein, profiting by the disaster of his predecessor, actually had a reserve on the field of Lützen, but still, at the very last moment, Knyphausen was able to lead an entirely fresh body of soldiers to check the advance of Pappenheim's infantry from Halle, and at Lützen, as at Zama, the last reserves decided the result of the contest. It is needless to say that the successes of the king led to the universal adoption of his system. The testimony of antiquity was confirmed, and for the second time in history the phalanx succumbed to the legion.

The king's army had doubled its strength during his six months' occupation of Pomerania. Many important military positions had fallen into his hands, and he had established a safe base for ulterior operations. But, notwithstanding his alliance with France, his political prospects were but little improved. The general rising of the Protestants, which was expected to follow his landing, had not taken place. The Protestant Electors of Brandenburg and Saxony, whose states lay directly in his line of march, were rather covertly hostile than absolutely neutral. They refused the Swedes a passage, while they winked at the transport of Imperial detachments and stores through their territories. They even signed a convention, evidently aimed at the king, by which they bound themselves, while reserving their obedience to the emperor, to resist by force of arms any attempt to violate their frontiers. The emperor, as a matter of course, respected for the present a neutrality which at once protected the march of his armies and cooped up his antagonist in a narrow and barren tract at the very extremity of his dominions.

As matters stood, the chances of success were all in the emperor's favour. It was not to be expected that Gustavus would continue to carry on the contest without a single influential ally on German soil. It was only necessary to avoid any decisive engagement, and to let matters take their course. Gustavus abandoned to his own resources must have returned to Sweden in a few months. After this the emperor might have dealt with the Protestant princes as he would. But the court of Austria was impelled by a blind passion, which drew down on its head the indignation of the whole world. A terrible calamity was needed to rouse the Protestant powers from their apathy, and it was soon given them in a scene of inhumanity and horror, happily almost unparalleled in the history of the human race.

Tilly had formed the siege of Magdeburg, which had declared for the King of Sweden, early in the year 1631. Called away by the reports of the king's progress, he left Pappenheim to continue the investment, while he himself endeavoured to force the Swedes to an engagement. Foiled in this attempt, and crippled in his resources by the loss of his magazines by the capture of Frankfort-on-the-Oder, he retraced his steps to Magdeburg, and resumed the command of the besieging army on the 30th of March, 1631.

The burghers, though torn by intestine faction, held out gallantly. They had indeed refused the offer of a Swedish garrison, but had accepted the services of one of the most experienced of the Swedish generals.

Powder soon ran low, and starvation stared them in the face. Still the mention of surrender was forbidden on pain of death. It was confidently hoped that the siege would be raised in a few days by the arrival of the king. Yet week passed after week, and still there was famine in the streets of Magdeburg, and the foe before the wall. But the spirits of the burghers were kept up by constant communications with the exterior. Their spies brought them in almost daily reports of the progress of the king. On the 9th of May the hearts of all were relieved by the report that he was already within three days' march. The intelligence was confirmed by the rapid slackening of the hostile fire. Gun after gun was withdrawn from the Imperial works, brigade after brigade was seen retiring over the plain. There could no longer be any doubt that the king had nobly fulfilled his promise. The burgher guard quitted the walls, the whole population gave itself up to the transports of the hour. At night but few of the garrison returned to their posts. The whole city was soon buried in sleep. It was the last sleep of thousands.

Tilly had actually raised the siege on the assurance of the near approach of Gustavus; but the impetuous counsels of Pappenheim prevailed over his determination. It was finally resolved that the latter general should make one more attempt to carry the works by storm, but that if he were repulsed the siege must be definitively abandoned. Pappenheim immediately retraced his steps, and attacked the wall near one of the gates of the new town at seven o'clock in the morning of the 10th May, 1631. The few defenders were soon overpowered, and the general himself was the first on the rampart. Followed by a few brave men, he dropped into the street, and opened the gate to the assailants.

Falkenberg, the Swedish commandant, and after him Schmidt, captain of the burgher guard, aroused by the noise of firing, hurried up to the point of action. It was in vain that by exertions of almost superhuman valour they succeeded in driving the stormers back to the very gates: the walls, stripped of their defenders to feed the murderous conflict raging within their circuit, were scaled on a dozen points at once; Falkenberg fell almost at their foot, Schmidt soon shared his fate, and Madgeburg fell with his fall. The arrival of four fresh regiments of Imperial infantry crushed the last hopes of resistance; by noon the whole town was in the hands of Pappenheim.

Tilly now entered the city; his troops were disposed so as to occupy all the principal points and sweep the main streets with artillery; the burghers were ordered to retire to their homes on pain of death. A terrible silence reigned over the scene as the generalissimo rode down the long lines of soldiery. The fate of 40,000 of his fellow-creatures hung on one word of mercy from his lips. To his eternal shame that word was never spoken. Silently as he came, so silently he left. Immediately on his departure the soldiers burst their ranks, and flung themselves like famished wolves on the devoted city.

And now ensued a scene at which humanity shudders—horrors which the pen dares not portray. Men, women, and children, every age and either sex, were involved in one sweeping massacre. The ferocious soldiery of Pappenheim tossed little children from point to point of their pikes, or flung them, still living, into the flames. Fifty-three women

were beheaded in a single church. The city was set on fire in several places. A terrific tempest sprang up to fan the flames, and added the horrors of a general conflagration to the atrocities of a massacre that flooded the streets with blood. It was in vain that some German officers implored Tilly to spare the lives of their countrymen, nay, offered to risk life and limb in the cause of mercy. "The soldier has made extraordinary exertions, and must not now lose his reward," was the cold, stern reply. For four days Magdeburg was abandoned to her fate. In one day 6000 corpses were flung into the Elbe. When Tilly's second entry put a stop to this scene of more than fiendish barbarity but 1,400 of the inhabitants remained alive: forty thousand men, women, and children had been swept into eternity. Of the whole city there remained but a single church and a few wretched fishermen's huts. Never had such utter ruin fallen on home of civilized men since that fearful day when the soldiers of Titus gazed from the hill of the Temple on the tossing sea of fire that enveloped the crumbling ruins of the once holy city of Jerusalem.

A loud cry of indignation and horror rose up through the length and breadth of the land. As may readily be supposed, the chief blame was at first laid on the tardiness of the King of Sweden; he felt the imputation, and vindicated his conduct in an able and convincing state paper.

No one was more thoroughly aware of the necessity of an effective base of operations than the king. On abandoning his grasp on the coast it became necessary to secure his rear, by reducing the various towns held by the Imperialists in the Duchy of Pomerania, and driving them out of the country. By the success of these operations he found himself on the frontiers of Brandenburg. The Electors of Brandenburg and Saxony had resolved to close their territories against the march of either of the contending forces, and were prepared to enforce their decision by means of an army of 30,000 men. The king felt the difficulty of the situation. It would have been in the highest degree imprudent to advance so long as it was in the power of the two electors to throw so powerful a force on his lines of communication. It would have been even more imprudent to have attacked princes whose alliance was necessary to his success. To give them a pretext for a junction with Tilly would have been little short of madness—would, indeed, have brought his army to the very verge of annihilation. He therefore determined to try in the first instance the effect of negotiation; but his request for a passage through Küstrin was met on the part of the Elector of Brandenburg by a demand for the surrender of Spandau, recently occupied by the Swedes. The king, though chafed to the soul by this instance of ingratitude, withdrew his troops from the fortress without a moment's delay. But while the elector was congratulating himself on the success of his policy the Swedish army suddenly appeared before Berlin, and called on him to decide between peace and war. The defences of the city were too feeble to resist an attack, and the rapidity of the king's movements had frustrated all hope of an intervention on the part of the other elector. An accommodation was at last effected by the mediation of the ladies of the electoral family; the fortresses of Küstrin and Spandau were given up for the space of a fortnight to the king, and his way was thus opened up to the frontiers of Saxony. At this point the only available road was closed by a body

of Saxon troops; any advance in this direction would have led to an immediate engagement. Gustavus had come to fight for, not against, the elector: the permanent hostility of Saxony would have rendered it impossible for the Swedes to extend their operations into the heart of Germany, where the king was sure of an enthusiastic reception. Gustavus was therefore obliged to enter on a second negotiation, and while it was dragging on its tedious length received the terrible intelligence of the fall of Magdeburg. In the bitterness of his soul he avowed his intention of abandoning the war. Fortunately for his glory, he was roused by a letter from the Elector of Brandenburg, demanding, in a paroxysm of terror on account of the success of Tilly, restitution of the fortresses of Küstrin and Spandau, the term for which they were lent to the king having now expired. The king, roused to indignation by the insolence of this message, marched again against Berlin, and, by the threat of an immediate assault, forced the elector to an alliance offensive and defensive; this done, he entrenched himself strongly at Werben, about seventy miles north of Magdeburg. Here Tilly marched against him. But the generalissimo's career of triumph had culminated at Magdeburg. He was repulsed in two desperate attacks, and, having exhausted the surrounding country, was forced to retreat with a loss of 6000 men.

The emperor was now weary of the neutrality of the Elector of Saxony. Elated by the success of his army at Magdeburg, he conceived himself irresistible in the field. Accordingly he ordered Tilly to effect a junction with the division of Fürstemberg, and march into the electorate. The generalissimo was only too happy to have an opportunity of quartering his troops in the rich and untouched fields of Saxony. He marched forthwith on Leipsic at the head of an army of 40,000 men. The elector protested in vain; Tilly continued his march, plundering, burning, and slaying as he went. At length, after a pitiable attempt at bravado, and an equally pitiable display of vacillation and terror, the elector threw himself into the arms of Gustavus, and had the mortification to find his outpourings of enthusiastic admiration and inviolable attachment received with the coolest indifference. In answer to his frantic appeals, the king, who had every cause to distrust his fidelity, demanded concessions of the most humiliating character. The elector, on his part, was only too willing to grovel in the dust before his expected deliverer. The king's demands were not merely acceded to, but even exceeded. On receiving this proof of the earnestness of his new adherent, Gustavus gave way at once to the natural nobility of his temper, and, stipulating only for the loan of a sufficient sum to supply his army with one month's pay, broke up his camp and directed his march on Saxony.

Now occurred one of the most critical junctures of the war. Tilly lay at Leipsic with about 40,000 men. The armies of the elector and king, each about 18,000 or 19,000 strong, lay at a distance of about two marches from him and from each other. From his position and his enormous superiority in force he might have dealt his blows to right and left in quick succession, and with terrible effect, or at all events have endeavoured to hold the king at bay for twenty-four hours with the division of Pappenheim or Fürstemberg, while he overwhelmed the Saxons with the rest of his army. Subsequent events showed that the forces of Saxony

would have proved anything but formidable antagonists. The Tilly of bygone years would not have hesitated for a moment; but the Nemesis of Magdeburg hung over the soul of her destroyer. The general who had declared that in a match with so skilful a player as Gustavus Adolphus it was dangerous to lose the most insignificant piece, now all but threw up the game. The king without meeting the slightest opposition effected a junction with the Saxons at Düben, about ten miles in front of Tilly, on the 4th September, 1631.

Gustavus had now many reasons to force an action. His army was as strong as ever he could hope it to be, while a few days would bring large reinforcements to his enemy's camp. His only fear lay in his doubts of the steadiness of the raw levies of Saxony. Should they prove unequal to the assault of the veterans of Tilly, the Swedish army might be called upon to defend its positions against an enemy of more than double its strength. The elector used all his eloquence in the council of war against the possibility of such a contingency. It is not likely that Gustavus had any great respect for the arguments of his ally, still, after mature deliberation, he issued tho order to advance.

On the other hand, Tilly was unwilling to commit himself to the chances of an action before the arrival of the strong corps of Tiefenbach and Altringer. But the impetuosity of Pappenheim triumphed over the scruples of his leader. Yet men said that many an omen of ill had filled the superstitious mind of the general with gloomy anticipations of defeat. Perhaps his foregone conclusion as to the hopelessness of success may have contributed to his failure on the great day of trial. All his former military ability seemed to have deserted him at this juncture, and the disposition of his army was such as almost to have ensured his defeat.

His position on the slope of a low range of hills overlooking a wide and level plain was formidable enough, but he managed to neutralise all its advantages by the grossness of his errors, both of omission and commission. He omitted the most favourable opportunities of checking the march of the king through the single narrow pass that led to the battle-field. He permitted him to deploy calmly and leisurely into line. He drew up his own forces in one long line of heavy unmanageable brigades. There was not so much as a single regiment in reserve, and, worse than all, the whole of his artillery was posted on the hills far in rear of the main body of the army. It is quite plain that beyond a certain point any forward movement of the Imperialists would effectually silence the fire of their own guns; nor could these latter, cumbrous and clumsy as they were, be easily moved down to support an advance. And lastly, there was no force whatever at hand to repel an attack on this arm by any hostile body that might penetrate into the rear of the Imperial army.

The accompanying plan (Plate I.), which has been constructed from a comparison of the histories of Bulow and Chapman, and the contemporaneous details of the Swedish Intelligencer, will show the dispositions of the two contending hosts on the eventful morning of the 7th of September, 1631. There is very great uncertainty as to many of the movements on both sides throughout this memorable day. The art of despatch-writing was then only in its infancy, and few of the hands that grasped the sword were conversant with the use of the pen. The whole history of the battle, in

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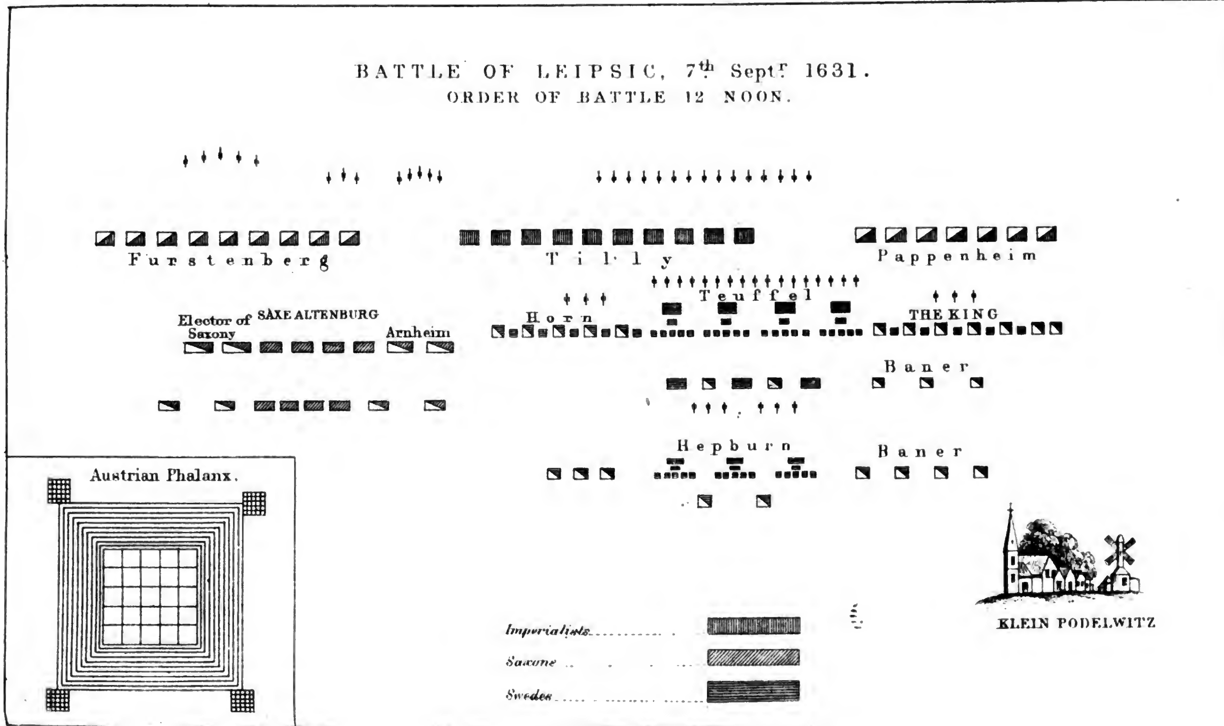

fact, is involved in the deepest obscurity. I have endeavoured to follow what seemed to me the most reliable authority on each point. If I have erred, I have done so at all events in good company.

Between the two armies lay a wide plain, which had been recently ploughed, and was now parched by a long continuance of drought. The sun and the wind were both in Tilly's favour, and the latter, sweeping over the fields, drove dense clouds of dust into the faces of the Swedes. A little before noon the king, in accordance with the chivalrous spirit of the time, sent a herald to Tilly, requesting him to commence the battle. The generalissimo responded by discharging three cannon-shots, which were answered by the Swedes with the same number. The cannonade now became general, and was kept up for two hours. Then Pappenheim drew his cavalry off to the left, for the purpose of outflanking the Swedes, and doubling up their whole line by taking them in rear. To counteract this design Baner, bringing up the seven cavalry regiments forming the reserve of the first line, drew them up at a right angle to the rear of the Swedish right. The line was completed by one of Hepburn's foot regiments of the second line, which took up the space intervening between Baner's extreme right and the village of Klein Podelwitz. Pelotons of musketeers were placed between the intervals of the Swedish horse, and the movement was effected with such rapidity, that Baner was firmly established in his new position before Pappenheim was able to come to the charge. As he came on with his wonted impetuosity, the Swedish musketeers delivered their fire with fatal effect among his crowded squadrons; and immediately afterwards Baner's cavalry broke in on his disordered ranks. At the same time the infantry regiment of Holstein Gottorp, which had followed the Austrian general from its post on the extreme left of the centre, being outstripped by the rapid advance of the cavalry, was left exposed in the middle of the interval between the two armies. Here it long made a gallant resistance with matchlock and pike to the repeated charges of the cavalry of Finland, but, its ranks being at length broken by the heavy fire of the Swedish artillery and musketeers, the Finlanders charged home. The Holsteiners still resisted with heroic courage, even after this disaster, but the Swedish sabres plied well their bloody work, and the whole regiment fell almost in the order of its formation.

While Baner was repulsing charge after charge by the tactics I have described, a terrible disaster had befallen the allied left. Tilly, in the first instance, led his own centre to attack the Swedish centre and left; but, his own batteries becoming masked by his advance, and being himself received by Torstenson with a withering fire of artillery that ploughed deep lanes through his heavy battalions, he was forced to retire to his original position. Here he attached himself to his right wing under Fürstemberg, and both generals now fell with the utmost fury on the Saxon army. The resistance here was for some time stubborn enough, but when the best of the Saxon cannoniers had been picked off by the Imperialists, and the long line of glittering sabres rolled on closer and closer to their van, they lost heart, broke, and fled in the wildest confusion, headed, as might be expected, by their gallant elector, and leaving their camp, and the whole of their equipage and artillery, at the disposal of the victors. Arnheim contrived to extricate two or three regiments of cavalry from the general

rout, and to lead them to a post of security behind the ranks of Gustavus Horn; the rest burst away with a celerity that might have been rivalled, but hardly exceeded, by a pack of beagles.

The position of the Swedish left was now critical in the extreme. Tilly in his pursuit of the Saxons had penetrated far into their rear, and, had this advantage been promptly followed up on his part, the Swedes might have had to mourn a signal defeat. But here one of the most fatal errors of the Imperialist system of warfare, that of allowing an army to degenerate into a band of plunderers, came in to thwart all his endeavours. The flight of the Saxons had left their camp exposed to the rapacity of the victors, and these latter, breaking their ranks, flung themselves like wolves on their prey. In a few minutes an organized body of at least 20,000 men had melted into a mere mob. It was only after a considerable interval of time that their generals were able to draw 8,000 or 9,000 men round their banners, and, covering these by the fire of the captured artillery, they led them direct against the Swedish left.

Gustavus Horn, one of the best generals of the age, had, however, improved the respite so unexpectedly granted him to the very utmost, by retiring the forces under his command till they formed an obtuse angle with the centre. The king also hurried up to the spot, and by his orders Hall's three regiments of cavalry attached themselves to the extreme left of the new position, and were there joined by the two remaining regiments of infantry of Hepburn's brigade; the centre regiment of the right wing was now ordered up to complete the line, and in a few minutes made its appearance at its appointed post.

And now ensued a struggle grim and great: pike crossed pike, sword clashed with sword, and man grappled with man; fiercely and sternly they fought, as wolf with wolf, as ship with storm, as river-flood with tide; regiment after regiment plunged into that wild tempest of fire and steel; regiment after regiment staggered back, torn and bleeding at every pore. Collenbach's Swedes perished man by man in their ranks as they had stood; Hall fell, as a soldier should, the first in a fiery charge. The legions of Austria rushed on again and again in one long line of glittering steel; again and again they reeled back, pierced through and through by the murderous fire of their foes. Faster yet thinned the Swedish ranks, but they still repelled every assault with the high-toned valour of a veteran army in whose breasts the lustre of a hundred victories has effaced the conception of defeat. Reducing their ranks to three deep, they still showed an impenetrable front, and poured in a fire that swept through the hostile ranks like the brand of a destroying angel. Meanwhile the king, by a masterly movement, decided the result of the day. Informed by Baner that Pappenheim after seven desperate charges had been driven in an eccentric direction from the field, and placing the utmost reliance on the persistence of the obstinate resistance of Hepburn and Horn to the dense masses of the enemy, he took the extreme left of his centre as a pivot and wheeled his troops round on this, so as to change the disposition from the two sides of an obtuse angle to a right line extending obliquely across the plain. By this magnificent manœuvre he rolled the detachments still occupying the enemy's original line of battle one upon the other, chased them in the utmost disorder from the field, carried

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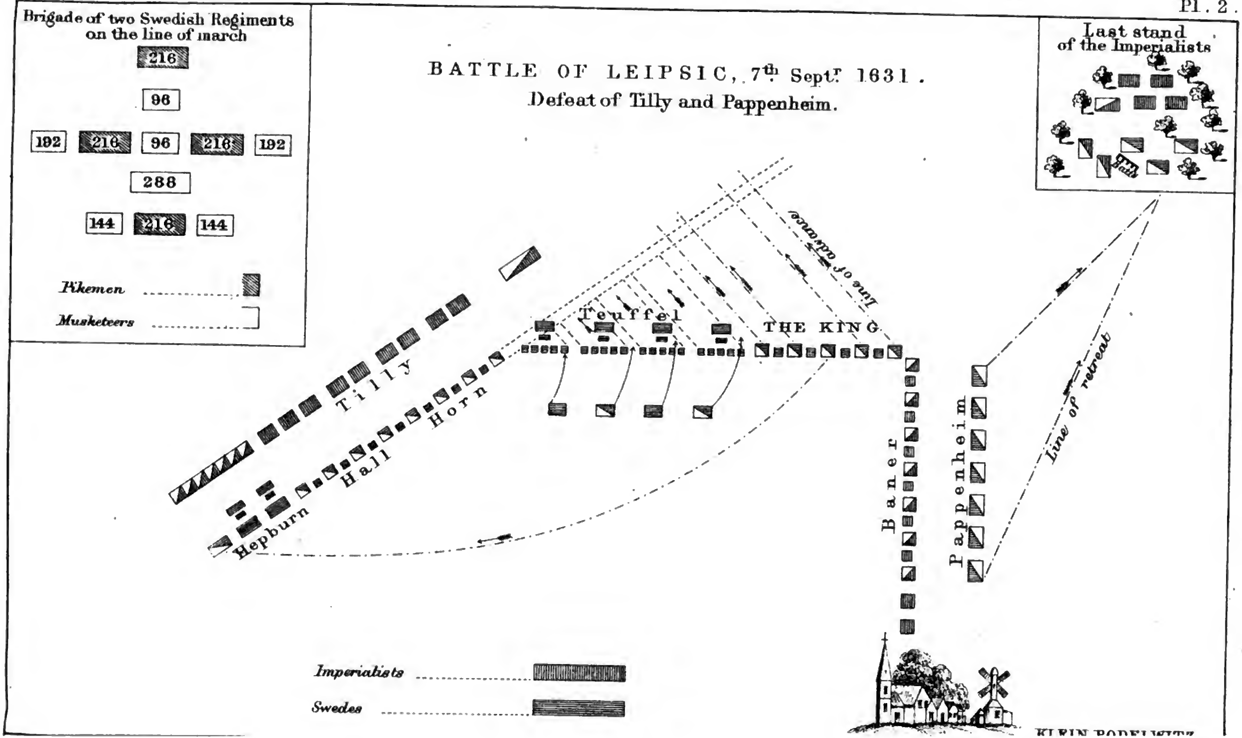
Pl. 2.



battery after battery, till the whole hostile artillery had fallen into his hands, and immediately brought it to bear on the rear of the Imperialists. The turning point of the battle had now come. Arnheim's Saxons plucked up heart of grace to charge the enemy in flank. Detachments from the Swedish right and centre came up rapidly on the rear of the enemy, already suffering severely from the fire of the artillery that had fallen into the hands of the king. Horn seized the moment of Arnheim's success to rush on with his whole line, and the Imperialists wavered, broke, and fled before his charge. Four regiments of infantry and one of cavalry alone sustained the ancient reputation of the Imperial arms. Closing their ranks, they burst through the circle of their enemies, gained a small wood in rear of Tilly's first position, and held it with heroic valour against all the efforts of the king in person till the shades of evening fell. Then, reduced to 600 combatants, they took advantage of the darkness of the night to retire from the position they had so long and so gallantly maintained.

So was fought the famous fight of Leipsic. The conquered army melted away into a mere mob. Eight thousand of their number were left upon the field; the whole of their artillery, as well as that captured from the Saxons, more than a hundred standards, and 500 prisoners, fell into the hands of the king. The loss of the Saxons was estimated at 2,000, that of the Swedes probably did not fall short of 1,500.

Material trophies were, however, the least valuable results of this glorious day. Not only had a victory been won, but a revolution achieved. The Imperialists, with every advantage of position and numbers, had been unable to hold their own. The legion and the phalanx after the lapse of centuries had met again in hostile array. Of the legion not a rank had been broken, of the phalanx but 600 had retreated with untarnished honour, and but 2000 presented themselves at headquarters on the night that succeeded the battle.

The king's movements during the next few months are more important in a political than in a military point of view. Between September 1631 and April 1632 he received the submission of almost all Germany between the Elbe and the Rhine, the Danube and the North Sea. He was everywhere hailed by the populace with tumultuous joy. The Protestant states of the empire attached themselves enthusiastically to him. The outlying territories of the League fell into his hands. Bohemia was conquered by the Saxons. Creuznach yielded to the chivalrous daring of Lord Craven, Donauwörth to the martial genius of Hepburn. Nüremberg, the richest and most powerful of the free towns of Germany, became the king's most devoted ally. Tilly, in consequence of superior orders, was forced to abstain from offensive operations, and to confine himself almost entirely to the re-organization of his army. Swedish detachments moved about in his vicinity with the most perfect impunity; even the king once gave him an opportunity of striking a blow with the greatest probability of a successful issue, but still his urgent request, urged almost with tears in his eyes, to be allowed to deviate from the cautious system enforced on him, met with a short and decided refusal. At length when the king, having destroyed all the outlying dependencies of the League, manifestly showed his intention of striking at its heart, the veteran was recalled to

the defence of Bavaria, the land of his nativity, and, taking up a position on the right bank of the Lech, between Augsburg and Rain, and breaking down all the bridges and seizing all the boats on the river, on the very verge of his fatherland, and at the head of the last reserve of his faith, awaited with a soldier's joy the approach of his antagonist.

The River Lech, ordinarily an insignificant stream enough, but now swollen by the melting of the winter's snows into a furious torrent, here swept round a point of land in the shape of an isosceles triangle, of which the vertex was turned towards the enemy, and the base formed by a small but rapid offshoot of the main stream. The legs of the triangle were lined with heavy batteries, behind these was a deep wood, still further in the rear a strong breastwork held by a large body of musketeers. Behind this again was the little stream just referred to; then came a huge redoubt, garrisoned by the bulk of Tilly's forces, and commanding the whole position by its fire. To the rear of all these extended a range of heights on which the army might form again if forced to abandon the shelter of their entrenchments. Finally, from the conformation of the ground, reinforcements could be despatched to any point along the chord of an arc, while the enemy's movements must be made round the circumference.

Gustavus Adolphus came up in force on the 3rd of April, 1632, and immediately undertook a close reconnaissance of the enemy's position. His eagle glance at once detected an oversight that utterly marred the efficiency of Tilly's scheme of defence. He saw in a moment that the generalissimo had entirely overlooked, or never attached the slightest importance to the fact, that the Swedish bank of the river was about ten feet higher than his own. To prevent Tilly's becoming sensible of this error, he contrived to withdraw his attention by various feints on the remoter portions of the line of defence, while by quietly taking possession of this post he secured at once a commanding elevation and a point from which he could direct a converging fire on the enemy. The whole Swedish army was trained to engineering operations, and, working on this occasion under the eye of their sovereign, they threw up during the night a formidable chain of earthworks, which, before dawn, were mounted with 72 heavy pieces of ordnance in three batteries, bearing respectively on the vertex and the two sides of the triangle. As soon as the light would permit, they opened fire. Their balls, crossing each other in three directions, swept everything before them, effectually preventing the despatch of reinforcements from the rear, and, tearing huge branches off the trees, flung them among the Imperialists, where they bore down whole ranks at a time. The enemy replied with vigour, but from the lower level of their batteries their shot generally struck the bank or passed over the heads of the Swedes. It so happened, also, that the wind was blowing fresh from the Swedish to the Imperial camp, and the king, ever alive even to the most trivial point in his favour, forthwith ordered large fires of wet wood and straw to be kindled all along the front of his line, and the smoke from these and the artillery floating across the river, soon enveloped the Imperialist lines in dense clouds of vapour. Under this cover a small body of Swedes crossed the stream from their own right, and, unperceived by the enemy, threw up a triangular breastwork, of the kind then called a sconce, as well for their own protection as to serve as a *tête de pont*. A

bridge had meanwhile been prepared, and was thrown across during the night, and the whole army received orders to prepare to cross over on the following morning. But the passage was already won without their knowledge. Tilly had fallen mortally wounded about noon, and with him the confidence of the army. Any further resistance was intended merely as a cover to a foregone resolution to retreat. The Duke of Bavaria, who had succeeded to the command, led the army out of the entrenchments under the shade of night, and finally, acting on the dying advice of the generalissimo, abandoned his capital and his territories to the victor, and seized the important city of Ratisbon, behind the strong fortifications of which he was not only secure against any sudden attack on the part of the king, but was placed in the most favourable position for covering the route of the army that was fast assembling under the banners of Wallenstein on the frontiers of Bohemia.

After the battle of Leipsic the Imperial Court had again opened negociations with this great commander, then living in sullen retirement, but in more than royal splendour, on his vast Bohemian estates. After a long negociation, in which the pride of Vienna was humbled to the very dust, he at length accepted the command of an army to be raised in his own name, to be officered by his own creatures, and to be as absolutely under his own control as the Swedish forces were under that of their own sovereign. The urgency of the case in time overcame the scruples of the Imperial advisers, and Wallenstein was empowered to open recruiting places in all parts of the Austrian dominions, and in three months found himself at the head of an army of 40,000 seasoned soldiers. With this force he drove the Saxons out of Bohemia, forced the Elector of Bavaria not merely to join him with his army, but even, to the inexpressible chagrin of the latter, to submit to his authority as generalissimo, and then, turning the heads of his columns westward, marched straight on the free city of Nüremberg, the most devoted of the allies of the king.

Wallenstein's plan of operations was boldly and ably conceived, was indeed of the very highest order of strategy. The king, conducting a campaign in lands which had been but recently subjugated, and in many of which there existed a party strongly opposed to his authority, had been compelled to divide his forces into seven corps d'armée. His left wing rested on the shores of the Baltic, his right on the eternal snows of the Alps. A hundred and twenty thousand men served under the standard of Sweden; his opponent could muster but half the number; yet with these he was about to throw himself in overwhelming strength on the most vital point of the Swedish line, threatening to divide their whole army in two, and to intercept the king's communications with his own country. So ably were his measures conceived as to leave Gustavus no choice between hurrying up to the defence of Nüremberg with whatever forces he could call round him at the moment, and abandoning the contest. It was hardly to be expected that, if Nüremberg should prove a second Magdeburg, even the most devoted of the king's allies would feel themselves bound to keep faith with a general whose cautious tactics had led him to prefer his own safety to a march through friendly countries to the relief of a great and flourishing city, whose only error had been its entire devotion to his cause. The soundness of Wallenstein's reasoning was proved by the result. The

king, seeing at once the critical nature of the juncture, arrived almost unattended in Nüremberg, marked out the limits of an entrenched camp, exhorted the burghers to strain every nerve as well to complete it according to the plans he furnished as to surround their city with walls, promising at the same time to return to them in a few days with as imposing a force as he could muster. The citizens carried out the king's recommendations with spirit and energy. Several thousand labourers were at once set to work. On the seventh day after the digging of the first trench the king's army, 16,000 strong, entered the entrenched camp; on the fourteenth the works were reported to be fully completed.

Fortunately for the city, Wallenstein's rate of progression at this crisis was not remarkable for its rapidity. His inactivity was probably a part of his general plan, and was assumed for the purpose of giving the king full time to fall into the trap laid for him, and of forcing him to risk a battle before Nüremberg with an enemy of nearly four times his own strength. His own boast, indeed, while on the march, that four days would show who was to be master of the world, he or Gustavus Adolphus, seems to point irresistibly to this conclusion, and his subsequent conduct to show how little he was prepared for the barriers opposed to his progress by the vigorous and rapid measures of the King.

The famous camp of Nüremberg, the Torres Vedras of Protestant Germany, formed a vast circle round the city; was defended by a chain of redoubts, batteries, and lunettes, mounted with upwards of 300 pieces of artillery, and held by an army of 16,000 disciplined soldiers, who might at need receive considerable assistance from the city itself, the whole youth of which had been organised, and was being rapidly trained to arms. It was watered by the River Pegnitz, which divided it almost into equal portions, and supplied with the necessities of life by the magazines of Nüremberg, which had been stocked with a full year's supply of provisions, and indeed for many weeks continued to send from 40 to 50,000 pounds of bread daily into the camp. Finally orders had been sent to Oxenstjerna, chancellor and general of Sweden, to collect all outlying detachments of the army, and hurry up to Nüremberg with every available horse and man.

The army of Wallenstein, fully 60,000 strong, arrived long before the full completion of the Swedish works of defence. His lieutenants, taking into account the great disparity of numbers between the forces, and the inadequacy of the king's means to supply every portion of so vast a circle of fortifications with a competent garrison, urged an immediate attack. But even Wallenstein's resolution failed before that grim array of earthworks. "We have had enough of battles," said he, "let us now try a campaign of famine." He accordingly entrenched himself on and at the foot of a series of heights, about four miles to the west and south-west of the king, and there patiently awaited the result.

And now ensued one of the most terrible struggles recorded in history. Two armies, the total numbers of which, before the conclusion of the contest, amounted to 120,000 men, independently of the population of Nüremberg, swollen to nearly the same number by the influx of the inhabitants for many miles round, sat quietly down to test each other's endurance of pestilence and famine. Strange to say too, the originator of this fearful

experiment seemed to be the very one who would suffer most from its effects. The city of Nüremberg, in spite of the vast numbers dependent on its resources, was long equal to every demand. On the other hand, Wallenstein had no magazines of any importance, and was obliged from the very first to depend almost exclusively on the surrounding country for his supplies, and, as this became exhausted, to send out foraging parties in circles, whose diameters increased sensibly every day, while the king, from a desire to bear as lightly as possible on the devotion of the faithful city, endeavoured also to procure from the same source the largest possible proportion of the food requisite for the subsistence of his army. As a natural result, the whole district became a scene of desperate encounters, in which success was generally on the side of the Swedes. One immense convoy of upwards of 12,000 cattle and 1,000 waggons fell into their hands after a combat that assumed almost the proportions of a battle. Famine now began to rear its head in the camp of Wallenstein, and pestilence went with it hand-in-hand. The king's army was indeed far from free from contagious disorders, but famine as yet there was none.

On the 15th day of the campaign of famine, Gustavus was joined by his long-expected reinforcements, and now found himself at the head of an army of 70,000 men. But this formidable accession of strength brought with it its perils as well as its advantages. At this point the resources of the heroic city broke down. There were neither sufficient mills to grind nor ovens to bake the daily bread of upwards of 200,000 men, women, and children. Famine now began to rage as fiercely in one camp as in the other. It is impossible to state Wallenstein's loss; but that of the Swedes was from 1,200 to 1,400 a-week. Gustavus, sick at heart of these scenes of misery, offered battle again and again; but Wallenstein, though suffering still more than his antagonist, refused to leave the shelter of his entrenchments. At length the king's patience gave way, and, on the 23rd of August, 1632, the fifty-eighth day of the campaign, leaving his camp in charge of the militia of Nüremberg, he marched out, determined to force an engagement at all hazards.

Early on the following morning, the Swedish army drove in the Austrian outposts, and marched direct on the camp. Wallenstein's centre was posted on a range of heights between the rivers Biber and Rednitz. The hill and crumbling ruins of the castle of Altenburg formed the key of the position, and were protected against a hostile attack by deep trenches, redoubts, barricades, and palisades, and were mounted with a hundred pieces of heavy artillery. The only approach was by a tongue of land, so limited in extent, that not more than 500 men could advance at any one time to the attack, and the defence of this passage was entrusted to the approved valour of a body of 500 Scotch and Irish musketeers, under Captains Gordons and Butler. These choice troops held their own with a courage that has never been surpassed. Battalion after battalion, the flower of the Swedish army, rushed up almost to the very muzzles of their pieces, battalion after battalion recoiled under their steady, rapid fire. But every success diminished the number of the defenders, while the attack was constantly fed by fresh supplies from the rear. At length the Swedes burst through the enfeebled ranks of their antagonists, and forced their way to the very foot of the entrenchments. Here they were met by

a murderous front and flanking fire, to which they were unable to make any reply. It was no longer a battle, but a massacre. It was in vain that, with unrivalled courage, they attempted to hew down the palisades, or even to tear them up with their hands; in vain that regiment succeeded regiment in the bloody work from the vanguard to the last reserve. After a combat of ten hours' duration, the king was forced to withdraw, with a loss of 2,000 men. A single gleam of success had indeed relieved the disasters of the day, where Duke Bernhard of Saxe Weimar, the favourite lieutenant of the king, had carried a height that commanded the old castle. But even here fortune proved false, for the ascent being found impracticable for artillery, the duke was ordered to retire at nightfall. The command was conveyed to him by Sir John Hepburn, of Athelstaneford, the hero of Leipsic, who, though present only as a spectator, having quitted the Swedish service a day or two before, in consequence of a quarrel with the king, could not find it in his heart to refuse a service of danger at the urgent request of his old and once-loved leader.*

The Swedes withdrew, sadly and silently, to their camp. They had suffered their first repulse, and, for the first time, felt the bitterness of defeat. Wallenstein, on the other hand, had justified the high value he had set on his services, and, for the first time for upwards of two years, had dispelled the gloom of the court of Vienna by the strange tidings of a victory.

Gustavus remained a fortnight longer before Nüremberg, but then pity for the faithful city and valiant army that were pining away under the combined influences of pestilence and famine overcame his resolution. On the seventy-second day of the campaign he again offered battle, nay, even tempted fortune by marching his army almost round the hostile camp in the vain hope of luring Wallenstein to the encounter. The generalissimo looked on calmly as regiment after regiment filed by his inaccessible post. Enough of battles had been fought, and he had succeeded in the campaign of famine.

The king, leaving a strong garrison in Nüremberg, now marched into Bavaria for the purpose of reducing the few towns that still held out for the elector. From thence he was suddenly recalled to the scene of his former triumphs.

Wallenstein, possibly for the purpose of intimidating the elector by the actual presence of danger into an alliance with the emperor, had taken

* A few words as to the after-fate of this gallant officer may not be out of place. After resigning his Swedish commission, he was appointed to a high command in the army of France, and subsequently became colonel-in-chief of the Scotch regiments transferred from the Swedish to the French establishment. While serving in this capacity, he fell mortally wounded at the siege of Saverne by the side of Henri de la Tour d'Auvergne, afterwards known to history as the great Turenne. The baton of Marshal of France, at that moment on its way, arrived only in time to be placed on the hero's bier. His Scotch followers, transferred to this country in the reign of Charles II., were embodied in a regiment that has since upheld the glory of England for two centuries in every quarter of the globe, with a courage that no peril could daunt. Long as the fame of England lives, long as there is honour for discipline, valour, and endurance, long as the historian's page and the poet's song glow with the memories of the deathless brave, in lowly cottage and in lordly hall there will be warworn veterans to boast that the flame of valour shone no more brightly in the breasts of Hepburn and his companions than in their military descendants of the present day, the First or Royal Regiment of the Line.

the opportunity of leading his army into Saxony during the absence of the electoral army in Silesia. His army behaved on the present occasion with even more than their accustomed cruelty. The fields were plundered, the villages burnt, and the peasants murdered all along the line of march. In his distress the elector appealed again to Gustavus, and was not deceived in his estimate of the generosity of his ally. The king hurried up to Nüremberg at the head of a small body of cavalry, dispersed the Imperialist detachments in the neighbourhood, and, having thus provided for the safety of the city, withdrew the greater portion of the garrison, and passed, by forced marches, towards the scene of danger. Reinforcements flocked to his standard from all quarters, and, on his arrival at Naumburg, he found himself at the head of 20,000 men.

Wallenstein had thus a second time diverted the course of war from the territories of the League; and now, for the second time, found himself, though inferior in force on the whole, decidedly superior on the point of action. Changing his tactics, he now marched straight on Naumburg at the head of an army of 40,000 men and offered the king battle, which the latter in his turn refused, seeming at the same time so busily employed in the construction of an entrenched camp, that Wallenstein, fully persuaded that his opponent had resolved on a repetition of the campaign of famine, not only gave up all idea of any further active operations at so advanced a period of the year, and put his men into winter quarters, but even yielded to Pappenheim's entreaties to be allowed to march with nearly half the army to the relief of Cologne, then hardly pressed by the forces of Holland.

An intercepted letter from Count Colloredo betrayed the intelligence of this movement to the king, while almost at the same time he received information of Wallenstein's retirement into winter quarters in the neighbourhood of Lützen. "Verily," said the king, "the Lord hath delivered him into my hand." He immediately broke up his camp, and marched straight against the enemy.

Three cannon-shots from the tower of Weissenfels, where Count Colloredo kept watch and ward, announced to Wallenstein the approach of the king. His cool, clear, intellect rose at once to the level of the crisis. Orders were issued without a moment's delay to all his outlying detachments to fall in on the main body; and Isolani was despatched with a large body of cavalry to retard the progress of the enemy to the utmost. Messengers were also sent off in hot haste to command Pappenheim to retrace his steps and hurry up with his whole force. A position of considerable strength in the neighbourhood of Lützen (see Plate III.) was selected for the scene of action. As corps after corps came up it was marched off to its appointed station, till every favourable point along the whole line was manned by an adequate garrison. All night long mattock and spade were plied with energy and skill, till positions originally weak acquired all the elements of strength, and those that were naturally strong became almost impregnable. Hour after hour fresh accessions of strength poured into the camp, till the generalissimo, fully convinced of the completeness of his dispositions and fully confident of his ability to hold out till the scale should be turned in his favour by the arrival of Pappenheim, at length gave his wearied army the welcome signal of repose.

The treachery or incompetence of their guides impeded the progress of the Swedes far more than the opposition of Isolani. At length, after much tedious wandering to and fro, they found themselves at nightfall in presence of the enemy. The various corps took up their positions in order of battle, the whole army was ordered to stand to its arms before daybreak, and the attack to commence at the rising of the sun.

The king's order of battle varied but little from that which had been so successful at Leipsic. He drew up his army in two lines with a reserve to each, and intermixed his cavalry with musketeers as before. The high road from Weissenfels to Leipsic ran in front of his line at a distance of 400 or 500 yards. Behind this, but rather nearer to the road, lay the bulk of the Imperial army.

The disposition of Wallenstein's army remains a mystery to this day. My plan is derived from the Swedish Intelligencer, and shows the appearance that the Imperial army presented to an eye-witness on the day of the battle. By a manuscript plan in Wallenstein's own hand it appears that his infantry marched in twelve divisions to the field on the eve of the encounter. Eight of these, according to the Swedish Intelligencer, were visible in the first line. Following a valuable hint of the Rev. Mr. Chapman, I have adopted this arrangement, and placed the four other brigades in reserve. It is, however, only fair to state that the correctness of this view may be impugned, that the position of the reserve is founded merely on guess-work, and the whole must be simply taken at its value. It seems, however, almost impossible to suppose that a general of Wallenstein's ability could have repeated Tilly's error in drawing out his army in one long line without any reserve, or, as is generally reported, have massed his infantry in five huge squares, each flanked by a sort of turret of musketeers, four of these squares forming a diamond in the centre, and the fifth lying at some distance on the right. The very names of Wallenstein's lieutenants on the day of battle are as much a matter of question as the disposition of his forces. Some authors assign the command of the left wing to Holk, others to Gœtz. It is well known that the former was a considerable distance in the rear a day or two before the engagement, and I am therefore inclined to give this honour to Holk, who certainly was always present with the main body. The only thoroughly ascertained facts, indeed, as to the Austrian order of battle are the stern realities that presented themselves to the Swedes as they marched to the attack. Wallenstein had seized the highway in front of his position, had deepened the trenches that ran along its course, and lined them with a strong body of musketeers, supported by a battery of seven heavy guns in position on a slight eminence in the rear, and had secured a flanking fire by occupying a hill in front of Lützen, and at the right of his line. Three windmills that stood on the crest of this eminence were occupied by his troops. In front of these was a battery of fourteen guns, and several enclosed gardens in the immediate vicinity were strongly garrisoned, and their walls loopholed for musketry. Pappenheim had taken about 20,000 men with him, but it is more difficult to estimate the numbers of those who remained to contest the field. The totals given by different authors vary in amount between 12,000 and 30,000. From a comparison of authorities, and the appearance of Wallenstein's line of battle as shown on the plan, I should

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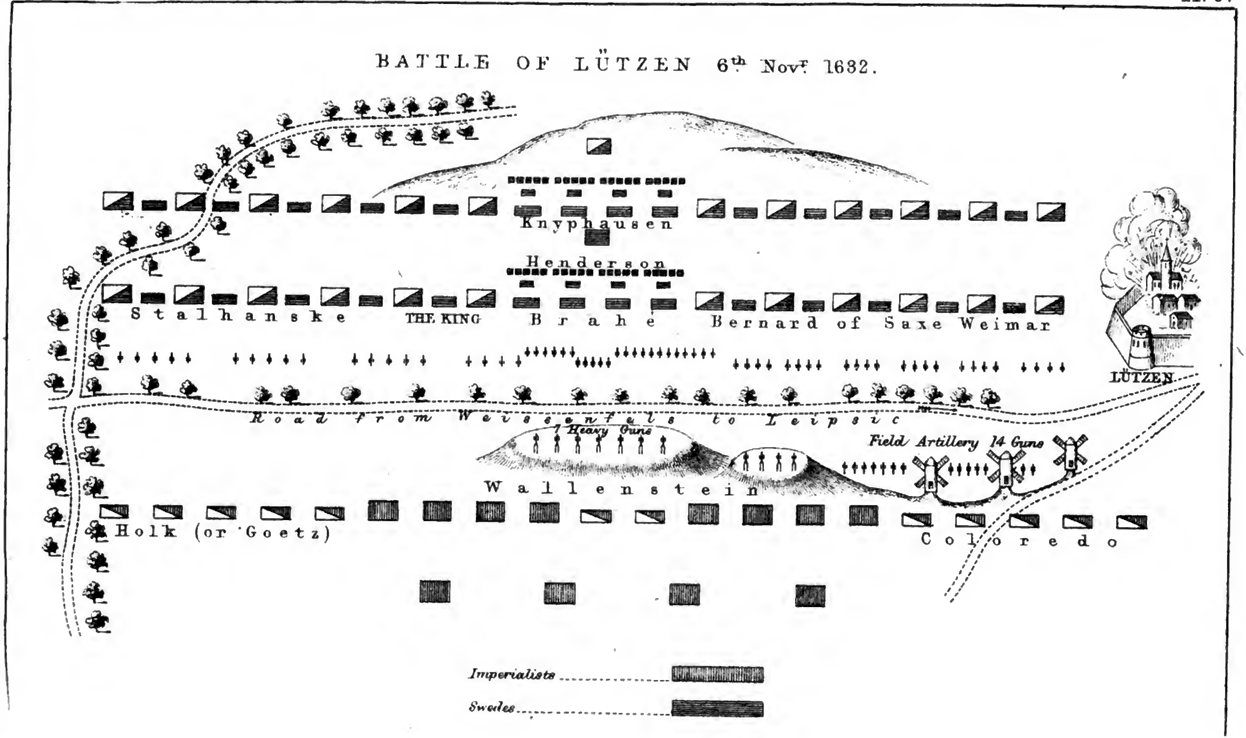


be inclined to think that he had about 25,000 men under his immediate command at the commencement of the engagement, while the king's forces could scarcely have amounted to more than 20,000.

The Swedes were drawn up in line of battle long before sunrise, but, so dense was the fog that brooded over the plain, that Gustavus, to whom every moment, in consequence of the proximity of Pappenheim, was of incalculable importance, was long compelled to delay the attack. At length, about ten o'clock, a few straggling rays penetrated the gloom, and were thrown back from the polished arms and glittering pikes of the Imperial army. The king at once gave the signal of battle, and placed himself, as in many a bygone day of glory, at the head of the right wing.

The whole first line of the Swedes now rushed to the attack. Far to the left Duke Bernhard scaled the hills in front of his position, carried the 14-gun battery, drove the defenders out of their walled enclosures, and penetrated to the very foot of the windmills. But at this point, attacked in flank and rear by the cavalry of Isolani, who had crept round under the friendly veil of the fog that once more enveloped the field in its vaporous wreaths, he was forced to retire step by step down the incline, till he reached the plain, where he halted to form his ranks afresh for a second and more desperate assault.

In the centre the Swedes, in spite of a galling fire of musketry, advancing with their accustomed impetuosity, cleared the ditches in front of their defenders, and still pressing forward, crossed the high road, captured the first battery, encountered and routed the two nearest brigades of infantry, and poured on in apparently irresistible strength through a yawning gap in the Austrian line. The battle seemed all but won in the first shock of arms, when Wallenstein, hurrying forward with a third brigade, rushed upon the Swedes, disorganized and isolated by the rapidity of their success. His fresh troops gradually drove their opponents past the battery, the high road, and the ditches, and almost to the position they had held an hour before. A thousand men had fallen, and not an inch of ground was gained.

The king at the head of the right wing fell on the enemy's cavalry directly in his front. He scattered the Croats and light troops like chaff before the wind, and after a sterner and more glorious contest drove Piccolomini's heavy cavalry off the field. At this moment he was informed of the disasters that had befallen his centre and left. Entrusting the command of the right wing to Gustavus Horn, and ordering Colonel Steinbok's Smäland regiment of cavalry to follow at full speed, he galloped towards the point of danger; unfortunately, in consequence of the density of the fog, and his own shortness of sight, gradually getting closer and closer to the enemy. An Imperialist corporal, who had observed the respectful manner in which every one had made way for the king as he passed along in front of his line, now ordered one of the musketeers beside him to take aim at the tall officer on the white horse, as it was evident he must be a man of distinction. The musketeer obeyed, and his shot broke the king's left arm. At this moment a squadron of Swedish cavalry, sent to cover their leader, rode up and received him into their ranks. A cry of terror rose among them at the sight of his blood. He endeavoured to reassure his companions at the first, but in a few moments, feeling the pain of the

wound intolerable, he requested the Duke of Saxe Lauenburg to lead him out of the battle. He had proceeded but a few paces when a second shot struck him in the back. "Brother," said he, "I have had enough; look to your own life;" and dropping the reins, fell heavily from his horse. Scarcely had he touched the ground when a charge of Croatian cavalry swept up to the spot. "Who are you?" cried out the foremost, struck by the dignity of his aspect, and the sight of the insignia of his rank. "I am the King of Sweden," he answered, boldly and resolutely, though with dying voice. The Croats rushed on immediately, not to save but to slay, and continued to heap wound on wound long after the noble spirit had quitted its frail tenement of clay. The body was now stripped naked, and would have been carried off but for the accidental arrival of a body of Swedish cavalry, who dashed in among the plunderers, and in their charge passed unwittingly over the spot where lay the remains of their heroic king.

It is beyond my purpose to enter into further details of the great battle of Lützen, the fiercest fight that ever raged on European soil. Suffice it to say that the Swedes, under the able conduct of Duke Bernhard of Saxe Weimar, annihilated in succession the army of Wallenstein, the cavalry of Pappenheim, and the infantry that followed his march from Halle. It was said that of the 45,000 Imperialists who at different times took part in the action scarce one escaped without a wound. Of 18,000 Swedes, Scots, and Germans who had stood in battle array that morning, but 9,000 gathered round the bivouac fires at night. The search for the body of the king was long continued in vain, but it was at length drawn forth, scarcely recognisable indeed but for its heroic proportions, pierced as it was by countless wounds, and torn and disfigured by the hoofprints of the masses of cavalry that had swept backwards and forwards over the spot throughout that long and bloody day. Brought to Erfurt, it was there consigned to the tears and embraces of the widowed queen. For eighteen months afterwards the coffin lay in her chamber. Every ray of light was excluded, and Maria Eleonora, dressed in deep black, sat day and night by the bier, as some said believing that a miracle would yet be wrought, and her noble spouse rise again to life from his narrow home. Twenty years later the sepulchre of the Vasas was opened again, that her worn and wasted frame might be laid by the side of him whom she had loved with a love that was stronger than death.

I have thus endeavoured to trace the military career of one of the greatest of modern generals during the two years that were the most glorious—but, alas, the last!—of his heroic life. The test of life is success. Misfortune may bear back for a while, but can never permanently check the onward course of genius. The victor of twenty campaigns has chained success to his standards, not by favour of fortune, but by superiority of intellect. The general, who, at the head of but a few thousand men, supported only by the resources of a poor and barren land, and deserted by the allies on whose assistance he had based his firmest hopes, yet in two short years bends beneath his sway lands ten times superior to his own in population, wealth, and military strength, who defeats every competitor in the field of war, who is the originator of a system of discipline that the experience of two centuries has confirmed, needs not the

feeble panegyric that these lips could bestow. Had his life been prolonged, what a wondrous page in history might have been bright with the records of his fame. All Europe in another year would have trembled before his frown. Monarchs at this day would have dated the origins of their lines from the campaigns of Gustavus of Sweden.

Yet, happy as he was in his life, happy in the love of two great countries, the cold kiss of the Angel of Death was perhaps not the least of the blessings showered on his brief but glorious career. Bright and straight and laurel-strewn was the path that the hero's feet had pressed, but the broad and flowery way that lay beyond stretched with many a deceptive bend towards the treacherous precipice to which the fair fiend Ambition was striving to allure him with silver voice and witching smile. In mercy Death strode between the enchantress and her destined prey, and saved him from a struggle in which even his resolute spirit might have failed.

In the thirty-eighth year of his life, in the pride of his manhood and the zenith of his fame, died Gustavus Adolphus, the Lion of the North. Old men have gone to their graves with the bitterness of a wasted life, of talents lost, of opportunities neglected. He met his doom in the summer of his days with yet the purpose of his life achieved. It was his hand that had stayed the onward march of a despotism that had threatened to involve the world in one vast monotony of slavery, his hand that hewed down the Medusa whose weird gaze was petrifying the life-blood of the young nations of Christendom. His epitaph is written in deeds. Of all men that ever lived he may most emphatically be styled the liberator of Europe, of this country as well as any other. Who can say what might have been our fate if Austria, unchecked in her fierce and daring attempt on the independence of mankind, had flung in the sword of a Tilly, a Pappenheim, or a Wallenstein, at the time when the cause of our constitutional liberties was trembling in the balance.

The answer comes, comes from the fair and fertile lands where the stately city of Venice fades on the bosom of the sea, that she wooed with nuptial rite, with wreath and ring, with music and with song, in the days of her glowing youth; from the wide fields whence the Galician views with tears the mighty dome that, upreared by pious hands of old, still shades the sacred spot where moulder into dust the relics of a hundred kings of the high-souled races of Jagellon and Piast; from the boundless plains where the mighty of the desert mustered myriad and myriad strong, when the sword of the War God flashed in the summer's sun, and earth trembled to her centre beneath the conquering tread of the Scourge of God. And if no English voice mixes in the dirge of nations, widowed of the glories of the past and robbed of the future's hopes, thanks to the good swords that braved the tiger in his lair and shore him of his demon's strength; thanks to the god-like chief who won Truth her triumph and Liberty her existence with his own heart's blood; to the statesman, patriot, and hero, without fear and without reproach, to Gustavus Adolphus, the Lion of the North!

Friday, February 28, 1862.

MAJOR-GENERAL J. E. PORTLOCK, R.E. in the Chair.

THE IMPORTANCE OF A KNOWLEDGE OF GEOLOGY TO MILITARY MEN.

By F. W. HUTTON, Esq. 23d Royal Welsh Fusiliers, F.G.S.

THERE is in the army a wide-spread though undefined opinion that a knowledge of geology is useful to soldiers; but how, and in what way, it is useful, many officers are, I believe, quite ignorant; and seem to be much in the same predicament as some cadets belonging to the Royal Military Academy at Woolwich, who were asked the question at their examination two or three years ago: some answered that it was a nice amusement, and kept them away from the billiard table; others said that it was a fashionable science, and therefore all officers ought to have some acquaintance with it, so as to be able to talk about it in society; while others candidly confessed that they thought it was of no use at all.

It is to try to rescue Geology from this false position, and to show that the opinion of its usefulness is, in reality, well founded, that I venture to point out to you this afternoon some of its practical applications to military science.

I do not claim any originality for the remarks that I am going to make; they are simply collected from various sources, and I wish particularly to acknowledge the obligations that I am under to Sir C. Lyell's Principles of Geology, to Sir H. De la Beche's How to Observe, to Mrs. Somerville's Physical Geography, and to my friends Professor Ramsay and Mr. Godwin-Austen.

The advantages to be derived from a study of the physical sciences have been summed up by Sir J. Herschel as follows :

I. In showing us how to avoid attempting impossibilities.

II. In securing us from important mistakes in attempting what is, in itself, possible, by means either inadequate, or actually opposed to the end in view.

III. In enabling us to accomplish our ends in the easiest, shortest, most economical, and most effectual manner.

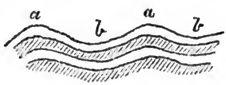
IV. In inducing us to attempt, and enabling us to accomplish, objects which, but for such knowledge, we should never have thought of undertaking.

My object is to show, in a general way, how Geology, the branch of physical science that investigates the structure of the globe on which we live, and the causes which influence that structure, bears upon these points; and why it is, to military men, by far the most important of all the sciences, and therefore the one to which their attention should be principally directed.

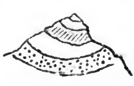
It is not necessary here to describe in detail, much less attempt to prove, the principal facts that have been arrived at by a study of our globe: I shall therefore take it for granted that the surface, or crust, as it is sometimes called, of the earth is composed of rocks, not scattered in confused masses over the whole world, but arranged in strata of sandstones, limestones, and clays, superposed upon one another in various orders; that these rocks were originally formed under water in a nearly horizontal position, then consolidated by heat, pressure, or by chemical agencies; and, after perhaps many oscillations, have since been raised into their present places by forces acting from below: that, in these processes, they have often been bent, broken, and pierced by other rocks, such as granite, greenstone, &c., which were at that time in a liquid state, and have since become hard: that the whole have undergone denudation * to an enormous extent, valleys having been scooped out and broken surfaces levelled; and that the present configurations of mountains, continents, islands, &c. are due to these causes.

If then we take for granted that the shape and direction of hills and valleys depend upon causes which it is the province of Geology to investigate, it is evident that the physical geography of a country cannot be properly understood until the geologist has shown how the mountains have been formed, and which are the principal axes of upheaval; for it is not always the most elevated ridges that are axes of upheaval; Ben Nevis and Snowdon, for example, the highest mountains in Scotland and Wales, are synclinals;† and, as the *military geography* of a country depends

* The wearing away of rocks by moving water. To show to what an enormous extent denudation has taken place, I may mention that Professor Ramsay has shown that the missing beds removed from the summit of the Mendip Hills must have been nearly a mile in thickness; and he has pointed out considerable areas in South Wales where a series of primary strata of not less than 11,000 feet, or more than two miles, in thickness have been stripped off.



† When strata are bent into undulations, a curve with its convex side upwards (*a*) is called an *anticlinal;* and the line running along the top of the curve, at right angles to the plane of the paper, and from which the strata slope, or *dip*, on each side, is called an *anticlinal axis*. A curve with its convex side downwards (*b*) is called a *synclinal;* and the line towards which the beds dip is called a *synclinal axis*. It is evident that a synclinal cannot have been an axis of upheaval; but it may form a mountain, as in the annexed figure.



entirely upon its *physical geography*, it follows that an acquaintance with Geology is necessary to be able to study it thoroughly; for, although a certain amount of knowledge can be obtained from maps and books, yet it is only by a knowledge of its geological structure and composition that we are enabled to form any correct idea of a country without actual inspection.

To explain: Unlike plants and animals, the same kinds of rocks are distributed all over the earth, and assume the same shapes wherever they may be; so that the knowledge obtained by studying them in one place is available for any other. Different kinds of rocks also form different kinds of mountains: some present high perpendicular cliffs with rocky inaccessible summits, bare of vegetation; others soft grass-grown slopes, with rounded outlines. Granite appears, when forming the tops of mountain ranges, in pyramids or wedges; when forming the main rock of a country, in truncated and shapeless masses. Gneiss and the crystalline schists occur in high sharp needle-shaped peaks with steep escarpments and deeply serrated ridges. Slaty rocks make a smooth and undulating country, but when slate is interstratified with hard schists it is rugged and precipitous. Trap and basalt often form perpendicular walls. The slopes of the unaltered sedimentary rocks are generally more gentle and rounded; but dolomite frequently appears in high abrupt peaks. Insulated mountains are generally of volcanic origin. That side of mountain chains nearest the sea is nearly always more precipitous than the opposite one—the south side of the Alps for instance, and the east side of the Alleghanies. In ranges that form the boundaries of lakes, or extensive valleys, through which great rivers flow, the mountains nearest to the river or lake have generally the steepest slopes. Rivers in a mountainous country are deep and rapid, usually with high banks, and are in general so much embarrassed by large stones as to be difficult for cavalry and impassable for carriages, while in plains they are sluggish, very tortuous in their course, often with low marshy banks, and are generally full of islands. When the strata, of which the country is composed, are arranged horizontally, large level plains and plateaux frequently occur, but this is seldom the case if they are inclined.

Again, as the nature of the country in which an army is to operate must always be taken into consideration, not only in all our own arrangements and combinations, but also with reference to the probable manœuvres of the enemy, it follows that its geological structure and composition must necessarily influence any movement, quartering, or matters connected with the subsistence of troops; and consequently all officers charged with any of these arrangements should possess a competent knowledge of that science. For, instance, in choosing ground for an encampment, especially if for any length of time, when the drainage would become of importance, geology lends its aid in many ways. It shows how to avoid wet clays, and where to find dry sand or limestone. In case of a scarcity of wood for fuel it points out where peat will most probably be found; occasionally even it might discover a bed of coal.

Peat is formed in stagnant basins from the rushes, sedges, mosses, &c. that grow in them; as these die they gradually fill up the hollow, and form a bog of loose spongy vegetable matter; the remains of the plants,

immersed in water, soon decay, become brown and soft, and are eventually converted into a black soap-like mass, called peat or turf. Small deposits of peat are found in almost every country: in mountainous ones, which are often nearly destitute of trees, the hollows are frequently filled with it; the constant assemblage of clouds upon the mountains favouring their growth by a gradual but incessant supply of moisture. These bogs are of course never extensive, and seldom exceed six feet in depth; still they might be of great use. Peat is often covered by a layer of sand or vegetable mould, and would not then perhaps be detected unless expressly sought for; it is always found in horizontal beds. It is prepared in Ireland by simply removing the surface soil, cutting it into bricks with a spade, and piling them loosely together to dry: when too wet to be cut, it can be moulded by pressure into bricks and then dried. The value of peat is in proportion to its dryness, density, and firmness; the longer it is kept and allowed to dry the more it will improve: even when well dried it contains about one-tenth of its weight of water.

During the war in the Crimea the allied forces were partly supplied with coal from Eregli (Heraclea), on the south coast of the Black Sea. In 1855 the English government were advised that this supply might be increased by following the direction of the beds across Bithynia, and a Mr. Poole was sent out to inspect and report; but he seems to have been guided by information obtained from the natives, and in every instance to have gone in search of superficial peat, of which abundance is to be found about the great lakes. What he ought to have done is this—starting from the coast section on the Black Sea, he should have made himself acquainted with the aspect and dimensions of the carboniferous beds, and followed them along their line of outcrop;* this he could have done, as there are no overlying formations, and he undoubtedly would have come on some spot where the coal-seams were in a convenient position for working from the surface, for they are very numerous. In this case a better geological survey would have been a great saving, for in 1855 coal, delivered in the Black Sea, cost the government 6*l.* a ton.

With respect to the water supply of camps, the geologist is often able to decide whether it is possible to obtain water by sinking wells, or whether they would have to be made so deep, before a supply could be obtained, as to be useless. Water is constantly passing upwards in the form of vapour from the surface of the land and sea; it is condensed into clouds by the coldness of the higher regions of the air, and falls to the earth again in the form of rain, hail, or snow; the greater part of it then descends into the earth, and is accumulated in the various rocks, from which it is discharged in the shape of springs. All rocks contain more or less water, but while in some it is kept there by mechanical means alone, and can therefore be easily obtained from it, in others it is held by adhesion, or capillary action, so that simple drainage will not extract it.

The two things in the structure of the earth's crust that principally influence the collecting of water, are the alternation of porous beds of sand and limestone with impervious ones of clay, and the faults and dislocations of the strata. When a hill is formed of a porous rock at the top, resting

* A stratum is said to outcrop when it comes to the surface.

on a bed of clay below, the water sinks through the upper stratum to the impervious one, and then, not being able to penetrate further, runs out in springs. The reasons why it forms distinct springs, and not a continuous ooze along the line of outcrop, are the frequency of fissures in the porous rock, and the inequalities of the surface of the subjacent clay.

There are two different kinds of springs which are caused by faults,* one where the water in a porous stratum is simply intercepted by the fault and diverted to the surface, the other where the spring is maintained by the water being forced up from below, as in Artesian wells.

To estimate approximately the quantity of water received each year in the rocks of any given district, we must know the mean annual rainfall at the place, the amount of evaporation, and the amount discharged from the surface by streams; this last has been calculated by M. Arago, for the valley of the Seine, to be about one-third of the whole rainfall. It is impossible to say what the amount of evaporation at any particular place may be, for it depends on the roughness of the surface exposed, and on the wind blowing over that surface, as well as on the density, temperature, and dryness of the air. The average rainfall at London is about $24\frac{1}{2}$ inches per annum, and it is considered a heavy rain if an inch falls in 24 hours. It may also be useful to remember that an inch of rain over an acre is about 100 tons, or 22,500 gallons, of water. Besides these, we must also know the absorbent power of the rocks, their dip and thickness, the faults and fissures in them, and the nature of the underlying beds.

The simplest conditions under which water is collected in the earth, are when a bed of gravel or sand rests upon a substratum of clay. Owing to the porous nature of these rocks, and the consequent rapidity with which they are drained, the supply of water from the shallow wells sunk in a bed of this description is very variable, and is greatly influenced by the weather; but it depends upon the area that is exposed to the rain at a higher level, and to the position and magnitude of the springs that flow from it; and, as an assistance for calculating what a well might be expected to produce, I may mention that loose sand or gravel will absorb about one-third of its volume of water, that is, about two gallons per cubic foot, and will part with nearly the whole of it by drainage.

The facility with which water can percolate loose and gravelly soils is very great. The Thames saturates the gravel through which it flows, between London and Richmond, to a distance of several hundred feet each time that the tide rises, which is drained again as it falls; so that the wells in this tract regularly ebb and flow. Cess-pools, &c. should therefore never be placed near wells of this kind, as the impurities would filter through from one to the other and render the water unwholesome.

It appears by the experiments of Professor Ansted that a moderately hard sandstone will absorb from four to five pints per cubic foot, and will part with most of it; and it is considered that, under favourable circumstances, a deep well in sandstone will yield daily, to hard pumping, about a million of gallons.

Limestone, such as the Northamptonshire oolite, will absorb from 7 to 8

* When the strata on one side of a fissure have been moved upwards or downwards more than on the other side it is called a fault. There is a fault at (c) in fig. 2.

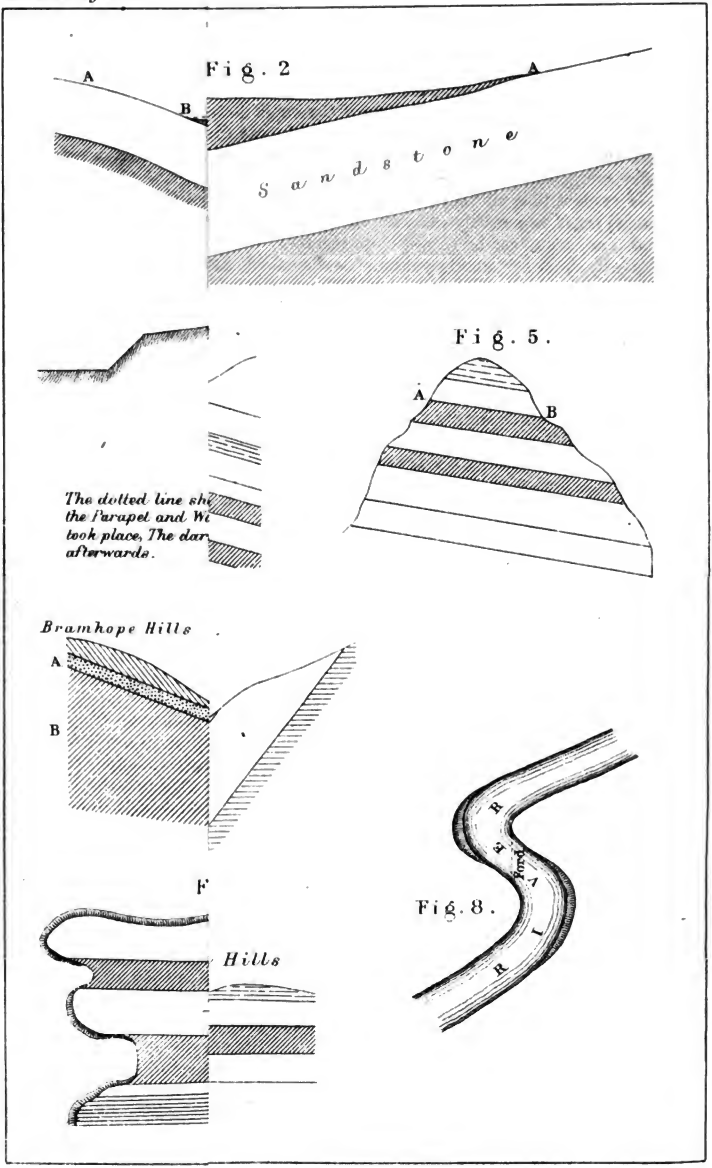


Fig. 2
A
B
A
Sandstone
Fig. 5.
A
B
The dotted line sh
the Parapet and W
took place, The dar
afterwards.
Bramhope Hills
A
B
F
Hills
Fig. 8.
RIVER
Road

pints per cubic foot; while chalk, like loose sand, will absorb two gallons per cubic foot, but will part with none of it by drainage; a well, therefore, sunk in it would never contain water if the chalk were perfectly compact; but it is found in practice that almost all rocks are full of cracks through which the water flows: this is the cause why wells sunk in a chalk country are generally so deep.

It is evident that all these wells, deriving, as they do, their water from drainage, must necessarily exhaust the surrounding rocks; two of them should therefore never be placed close together.

There is, however, another class of wells called Artesian, which, being supplied by the hydraulic pressure of large masses of water in the interior of the earth, may be sunk in close proximity. As these wells are of great depth, and take in consequence a long time to sink, they ought perhaps to be spoken of as an engineering operation, rather than having any connection with choosing ground for an encampment; but I think that it will be clearer, and take less time, if I introduce them here, together with the other means of water supply.

The principle upon which Artesian wells depend is explained in the diagram (fig. 1.) Let A B C D be a section across a basin-shaped valley, and let the shaded parts represent strata of clay, the unshaded part a stratum of porous sandstone. Rain, falling on the hills A and D, will soak through the sandstone, and, being kept up by the lower clay, will saturate the whole bed as high as the level of B C: it will then run over in springs. If now a well is sunk at H, through the upper stratum of clay into the sandstone, the water will rise in it, by the laws of hydrostatics, and, if it is on a lower level than B C, will overflow. If, however, it is on a higher level, as at K, the water will not rise above O. Of course, if B and C are not on the same level, the water will only rise in the wells as high as the lower of the two; and also, if the porous stratum is not saturated to the level of H, the water in it will not overflow.

In 1838 the total supply of water obtained by Artesian wells from the chalk near London was estimated at six millions of gallons a day, and in 1851 at nearly double that amount, the increase being accompanied by an average fall of no less than two feet a year in the level to which the water rose. The water stood commonly in 1822 at high-water mark, and had sunk in 1851 to 45, and in some wells to 65, feet below high-water mark. This fact shows the limited capacity of the subterranean reservoir.

It is absolutely essential for the formation of an Artesian well that the porous bed should lie between two impervious ones; but it is not always necessary that the strata should have a basin shape. Sometimes an impervious dyke * may cut through the porous stratum and so hold up the water; as in the diagram (fig. 2), where the water, stopped by the dyke C, would rise in the well B to the level of A. In this case it will be noticed that, owing to the fault at C, the water would overflow in the well, although its level is higher than the junction of the porous bed and the clay at C.

Artesian wells are of the greatest use in low and level districts, where

* When a mass of igneous rock such as granite or trap cuts through the strata it is called a dyke.

water cannot be obtained from superficial springs, or by ordinary wells of moderate depth; for it must be borne in mind that the hills A and D (fig. 1) may be at great distances apart. The chalk hills on either side London, for example, are some 40 miles distant from one another.

Artesian wells have, I believe, been successfully employed by the French military engineers in Algeria.

The principal causes of failure in sinking these wells are the numerous fissures and faults which abound in some rocks; the unexpected thinning-out,* and change in lithological character, of the rocks under ground, and the deep ravines and valleys by which many countries are traversed; for, where these lines of natural drainage exist, there only remains a small quantity of water to escape by artificial openings.

In sinking wells care must be taken, when the impermeable bed supporting the water is thin, not to cut through it; for by so doing the water would be let out into the rock beneath, if that should happen to be porous, as has very often occurred.

In order then to select properly the ground for an army to encamp upon, the sanitary officer attached to the Quarter-Master-General's department with an army in the field ought to have a good knowledge of Geology: in fact it seems likely that the healthiness or unhealthiness of a district depends chiefly upon its geological structure and composition.

Dr. Buckland, in the first chapter of his Bridgewater Treatise, says that "if a stranger, landing at the extremity of England, were to traverse the whole of Cornwall and the north of Devonshire, and crossing to St. David's, should make the tour of all North Wales, and passing thence through Cumberland, by the Isle of Man, to the south-western shore of Scotland, should proceed either through the hilly regions of the border counties, or along the Grampians, to the German Ocean, he would conclude, from such a journey of many hundred miles, that Britain was a thinly-peopled sterile region, whose principal inhabitants were miners and mountaineers.

"Another foreigner, arriving on the coast of Devon, and crossing the Midland counties, from the mouth of the Exe to that of the Tyne, would find a continued succession of fertile hills and valleys, thickly overspread with towns and cities, and in many parts crowded with a manufacturing population, whose industry is maintained by the coal with which the strata of these districts are abundantly interspersed.

"A third foreigner might travel from the coast of Dorset to the coast of Yorkshire, over elevated plains of oolitic limestone or of chalk, without a single mountain, or mine, or coal-pit, or any important manufactory, and occupied by a population almost exclusively agricultural.

"These dissimilar conditions of three great divisions of our country result from differences in the geological structure through which our three travellers have been conducted. The first will have seen only those north-western portions of Britain that are composed of rocks belonging to the primary and transition series (the Metamorphic, Cambrian, Silurian, and Devonian, of modern geologists); the second will have traversed those fertile portions of the new-red-sandstone formation which are made up of the detritus of more ancient rocks, and have beneath, and near them, in-

* When a stratum becomes gradually less and less in thickness in any direction until it finally disappears it is said to thin out.

estimable treasures of mineral coal; the third will have confined his route to wolds of limestone and downs of chalk, which are best adapted for sheep-walks and the production of corn.

"Hence it appears that the numerical amount of our population, their varied occupations, and the fundamental sources of their industry and wealth, depend, in a great degree, upon the geological character of the strata upon which they live. Their physical condition also, as indicated by the duration of life and health, depending on the more or less salubrious nature of their employments and their moral condition, as far as it is connected with these employments, are directly affected by the geological causes in which their various occupations originate."

From this we learn that even a general knowledge of the geology of a country would enable the commissariat officer to judge whether it is likely to be fertile or barren, and would point out to him where to look for corn, and where for forage, where for manufactures, and where for beasts of burden.

To the military engineer a knowledge of geology is invaluable, as has indeed been long recognised. In choosing building-stone, especially in countries not well known, he should examine those exposed in sections, ascertaining whether the sections have been caused by recent landslips, or if they have been in existence for ages. He must then examine how the stone has weathered, observing carefully if the changes have been caused by the chemical or the mechanical action of the atmosphere; that is, he should observe whether any of its component parts have united chemically with those of the air, or the substances contained in it, or whether it has been worn, and the edges rounded off, by the friction of water, or by the expansion of ice formed in the interstices of the stone. Care should be taken to note the structure of the stone, ascertaining if it is homogeneous, like compact limestone, or if it is composed of substances which, when exposed to the same causes of decomposition, resist them unequally: such as granite and conglomerate. Many stones are soft and easily worked when first taken from the quarry, and afterwards, on exposure to the air, become hard, owing to the evaporation of what is called the quarry-water contained in them. Some of these readily absorb moisture again, while others do not: hence the latter should be preferred. Some sandstones are always damp, owing to the deliquescent salts contained in them; this can generally be cured by washing them with sulphuric acid, which decomposes the salts.

For building breakwaters the specific gravity of the stone is an important consideration; as the greater the weight the greater is the resistance offered to removal. In constructing piers, bridges, &c. materials which are good for one part, may not be so for another: for instance, a porous sandstone, which may be advantageously employed if always kept under water, is liable to decomposition when exposed to the atmosphere, particularly in those situations that are kept alternately wet and dry by the rise and fall of the tide. Much information on this head can be obtained by studying the condition of rocks on the banks of rivers, and on the sea-shore.*

* Brard's method of obtaining the resisting power of stones to frost is a very good one. Boil the specimens in a saturated solution of sulphate of soda, and then hang them up in

Having settled which stone to employ, a knowledge of its dip will enable the engineer to trace it to other points, and thus open quarries in places where, but for the help of Geology, he would never have thought of looking.

A knowledge of Geology will also assist him in finding limestone for cement, sand for mortar, slates for roofing, &c. A case that occurred a few years ago at Portsmouth illustrates this. Cement was wanted in the construction of the new forts. This cement was made from nodules of calcareous clay called *septaria*, which come originally out of the London clay; but at Harwich, from whence the principal supply is obtained, they have been washed out of the clay and are dredged up in large quantities from the sea. Now the forts at Portsmouth are built on the same London clay in which these septaria are found; but, in ignorance of their nature, they were actually broken up to mend the roads, while others were brought by rail to make cement.

Geology will also help the engineer to judge if the rock on which he means to build will afford him a secure foundation. During the construction of Fort Elson at Portsmouth part of the escarp wall subsided, and slipped forwards; the clay being squeezed up in front of it, as is shown in the diagram (fig. 3). This was owing to its having been built upon the London clay. The treacherous nature of this clay, and its great tendency to slip, and be squeezed out when any weight is put upon it, is well known to geologists, and, I may add, to railway directors and engineers, the cuttings in it being always a source of trouble and expense. When the South Eastern Railway was first made, the slips in the cuttings through this formation were so great as occasionally to stop up the line; and even now the vibration produced by the passage of trains often causes slides to take place, or loosens portions in such a way that the next shower brings them down. If then the weight alone of the fort, and that even before it was finished, was sufficient to make the foundations give way, what might we expect to have happened after a day's heavy firing from it, and after a battering from the enemy's guns? Precautions have now been taken against these accidents; but, if the knowledge of geologists on the subject had been used, the expense of pulling down the sunken portion of the wall, and repairing it, would have been saved.

In constructing canals a knowledge of the geological structure of the country will often be a guide to the engineer as to the proper position of the summit levels, where he need not fear the want of water; and how to avoid porous strata, which would oblige him to go to the expense of rendering the canal-bed water-tight. It must be remembered that a knowledge of the rocks on the surface will not always give a knowledge of those that may be cut into along the line of a canal. A thin stratum of clay may exist on the surface, and rest upon a porous sandstone; and, in following the levels, the former may be cut through, and the canal-bed be based upon the sand.

In making roads the engineer will also find a knowledge of Geology of

a dry air. The salt in crystallizing will pretty accurately represent the force of water in freezing, and will chip off portions of the stone. These fragments being collected and weighed will represent numerically the resisting powers of the stones, the smallest of course being the best.

great use in showing him where to carry them so as to avoid a soft clayey bottom, which is always difficult to drain and render firm; where to find a hard and porous rock, easily kept in good order; how to avoid, or take precautions against, the springs that so often occur in the stratified rocks; and how to prevent slips taking place in his cuttings.

For example; Suppose that A B (fig. 4) is a section of a valley, along either side of which it is required to carry a road, and let the cross lines represent the dip of the strata that form it. Now to the non-geological engineer one side might appear equally as good as the other, but the geologist would at once see, that, if the road is made at A, it would most likely be wet, because the water would run down through the divisions between the strata ; that slips would take place if the dip is greater than the angle of repose; and that the cutting would require a slope at least equal to the dip: but, if the road is made at B, it would be dry, there would be no fear of slips, and the cutting might be made nearly perpendicular. If, instead of a valley, the road had to be carried along either side of a hill with the same dip (fig. 5), the case would be exactly the reverse, and the road shonld be made at A instead of B.

In 1843 the Leeds and Thirsk Railway Company projected a tunnel through the Bramhope Hills, from which issue the springs and streams that partly supply the Eccup Reservoir belonging to the Leeds Waterworks Company. In 1845 Mr. Curley, a civil engineer and also a geologist, was instructed by the Water Company to make a model of the district, for the purpose of illustrating the geological and engineering evidence required in opposing the railway bill before the Committees of both Houses of Parliament, and by which they succeeded in getting a clause introduced for compensating the Water Company for any loss of water they should sustain through the railway works. This diagram (fig. 6) will explain the facts of the case. The strata are part of the millstone-grit formation, A is a porous bed, and B is impervious to water. The rain, therefore, falling on the hills passes through until it reaches B, along the top of which it flows, and issues at the outcrop in springs which supply the reservoir. The porous bed being cut through by the railway works, as is shown in the diagram, the water was intercepted and carried into the tunnel, drying up the springs, as had been predicted by Mr. Curley. The pumping of the water alone out of the tunnel during its construction cost the contractor nearly as much as all the other works connected with it put together. Thus the Water Company, by employing the aid of geology, was saved from a severe loss, whilst both the contractor for the tunnel and the Railway Company, by ignoring that aid, incurred heavy expenses.

The inclinations at which cuttings and embankments can be safely made entirely depend upon the nature of the soil; clays generally requiring a slope of about 1 in 3, chalk marl 1 in 1, and sandstone or limestone 4 in 1. If strata of sandstone alternate with clays or marls, the inclination at which the slopes will stand, depends upon the dip. If the road runs along the line of strike * large masses of stone will become

* The line of strike is a line drawn at right angles to the dip of a stratum, and is the line along which it would come to the surface on level ground. Thus, if a bed dips north its strike is east and west.

detached and slip down over the smooth surface of the clay, even when the slopes are as much as 1 in 4 ; but if the road runs at right angles to the strike the slopes may be made 1 in 1·5. If the strata are horizontal, and the beds of marl are faced with stone, the slopes will stand at 4 in 1. In all cases where beds of sand or gravel are intermixed with clay drains should be cut along the top, and even in the sides of the cuttings, for if this precaution be not taken water will find its way into the gravel, and will by its pressure force the body of clay down before it, and slips will take place. All this evidently applies to the slopes of the ditches in field-works as much as to cuttings for roads.

On investing a fortress, a knowledge of Geology may often show the engineer where to find ground favourable for making trenches, and enable him to judge if it is likely to continue the same as far as the glacis; and I need hardly say how useful it might be in mining, although a military mine is never sunk very deep.

In blasting rocks much labour is saved by taking advantage of the joints and other divisions of the strata. To do this may seem very simple, and hardly to require much acquaintance with Geology, but it often takes an experienced geologist to distinguish between joints, cleavage, and planes of stratification.*

But it is perhaps, after all, to the staff-officer making a reconnaissance that Geology affords the greatest assistance, not only in sketching the country, but in supplying him with an immense amount of information about the position of villages, the supply of water, the character of roads, rivers, marshes, fords, &c.

With regard to surveying, its chief value is in a mountainous country. Mountains are generally found in groups intersected by valleys in every direction. These groups are often arranged in a series of parallel chains, the highest and most rugged of which occupy the centre; the lateral ones are constantly of less elevation and less bold in proportion to their distance from the central mass, until at last those most remote sink down into gentle undulations. To understand mountains properly we must consider the formation of valleys. Valleys, geologically speaking, may be classed under two heads, viz., valleys of elevation, and valleys of denudation. Valleys of elevation are formed either by the upheaval of the strata on each side of them, or by the sinking of the ground, leaving the adjacent rocks unmoved, or, as is most commonly the case, by lateral pressure, the strata in all cases being bent into a trough-shaped form. Valleys of this kind are broad, and at some distance from one another, forming a series of parallel ridges and furrows, the furrows being synclinal and the ridges anticlinal axes. Valleys of denudation are formed by the erosive power of running water. They are by far the most common, and their form is infinitely varied. This depends, however, on the hardness and direction of the strata. The main valleys generally run either in the direction of, or at right angles to, the strike, and the

* A plane of stratification is the line of division between two distinct strata that are parallel to one another. Joints are fissures in rocks produced by shrinking, &c., and are often at right angles to the planes of stratification. The term cleavage is applied to those divisional planes which render a rock fissile, but which generally are not parallel to the planes of stratification. Common slate is a good example of this structure.

smaller ones downwards towards the rivers and streams that drain the country, forming natural ramps from the lower levels to the higher.

Denudation has also always had some effect in modifying the shape of all valleys; partly by the action of the sea as they rose from the water, and partly by the action of ice, frost, and rain, after they had risen: for, however small may seem the power in rain-drops to wear away rocks as they trickle down the side of a hill, the effects that they have produced, by their continuous action through the untold ages of geological time, is so enormous as to impress the mind of the observer equally with the more magnificent phenomena of the volcano and the earthquake.

I know that it is quite possible for the professional surveyor to map all these things quite correctly without understanding anything about them, but to the military officer, whose great object is to combine correctness with rapidity, a clear idea of the Geology of the country that he is surveying is of immense assistance. Even in a district that is not mountainous, a knowledge of the thickness, inclination, composition, and order of the strata will greatly help him in obtaining the correct form of ground, and the proper position of the line of watershed; and will even sometimes enable him to detect errors in the plan of a country which he has never seen. But it is chiefly the constant habit of examining the surface of the land, and noticing the shapes of hills and valleys, that gives to the geologist an eye quick to take in the form of ground, and to distinguish between the principal and the minor features.

The position of houses and villages depends a great deal on the physical conditions of the country. For example, suppose a district to be composed of a stratum of sand between two beds of clay, the lower clay would be sure to be wet and marshy, for it would be overflowed by the drainage of the overlying sand, consequently but few houses and villages would be built upon it. There is a line of villages all along the base of the chalk escarpment north-west of London, the sites of which are determined by the springs.

With respect to roads, the reconnoitring officer has to observe of what they are made, and whether they are likely to become impassable in bad weather. In this Geology can assist him. When carried over sand, or a porous limestone, and made with good material, they are generally good in all weathers; but, if made on clay or other impervious rock and not well drained, they are sure to be cut up during rain. If the road is on the side of a hill, the dip and composition of the strata should be noticed to see if it is liable to slips, as is often the case when it rests on a sand or clay.

He has also to find out what are the best materials for repairing the roads and where they can be got. In choosing these he must recollect that they will be exposed to a crushing action as well as to friction among themselves, and that therefore tough as well as hard substances are required. By toughness I mean the resistance that a body offers to be broken or torn, in opposition to brittle. Rocks differ very much in these qualities; gypsum, for instance, is soft but tough, flint is hard but easily broken, while some are both tough and hard, as chert. Rocks which are composed of substances of unequal degrees of toughness are greatly inferior to those which are of the same texture throughout; thus granites

generally afford a material inferior to many trap rocks. Those granites in which the felspar is well crystallised are the worst for road purposes, since this mineral soon crumbles under pressure; while the granites in which hornblende prevails and the felspar is more compact are the best. The trappean rocks vary considerably in value as a road-making material; even the same quarry will afford stone of different degrees of toughness. Slate and limestone make smooth roads, but wear away rapidly when wet; some limestones, however, as the Bristol limestone, make good ones. Sandstone is much too weak for the surface of a road; it will never make a hard one.

The materials used in the construction of the road in the Crimea from Balaclava to the front, were whatever happened to be nearest. These from the harbour to the top of the plateau were oolitic limestones and sandstones, and all the rest of the way soft tertiary rocks. Now the whole of these, with the exception of a hard crystalline limestone in the oolitic series, are very inferior materials for roads, and when there is much heavy traffic, as was the case in the Crimea, are sure to be soon ground down into mud. But the beach outside the harbour of Balaclava is composed of compact greenstone, the very best road-making material known; so much so, that large quantities of it are brought from the Channel Islands for the streets of London; and if a geological survey of the country had been made this must have been found, and a good military road would in all probability have been made with it.

When operating in a mountainous country it is often most important to know whether a valley in the vicinity of the enemy can be safely traversed by troops, or whether it would be dangerous to attempt it in consequence of not being able to take possession of the heights on either side. Whether this is possible or not will depend upon the nature and hardness of the rocks, and on their power of resisting decomposition. Those rocks which weather easily will have smooth sloping sides, while those that do not will be bold and precipitous, and this is especially the case where soft rocks are interstratified with hard ones. No definite rules can be laid down for guidance, but there is a kind of instinct that seldom errs, which it is impossible to express in words, but which is founded on a close acquaintance with mountains, that enables the geologist to judge with tolerable certainty as to the nature of a valley, and whether its summit is likely to be inaccessible.

Mountains are in general most easily ascended from the side towards which the strata dip.

In looking for passes from one valley into another, either to turn the enemy's position, or to take precautions against our own being turned, it should be remembered that most of them are made by excavations in slate. The reason of this is obvious. As the ridge rose from the sea the soft slate would yield more to the action of the waves than the hard rocks on each side, and a depression in the ridge would be the consequence (fig. 7). The subsequent action of frost on such a fissile substance as slate would cover the sides with *débris* and make them smooth. If, therefore, a bed of slate can be discovered, it should be followed up to the top of the ridge, and a pass will most likely be found.

The nature of trees in forests, and the presence or absence of underwood

in them, depends greatly upon the soil on which they grow. Forests on a loose sandy soil are generally composed of firs and larches, with little or no underwood, and afford hardly any obstacle to infantry, while strong clay soils grow oaks and other trees, and support a thick mass of briers and small bushes, which often render them impassable.

The knowledge to be derived from geology about rivers and fords is very considerable. It has indeed been said that the course of all rivers is changed when they pass from one geological formation to another. This is perhaps rather too sweeping a conclusion, still there can be no doubt but that a change in the formation frequently causes a change both in the direction and character of a river, and that sudden deviations in their courses are often owing to dislocations of their beds.

The direction of a river depends of course upon the direction of the valley through which it flows. In a country where the principal valleys are valleys of elevation the principal rivers will run along them in the direction of the strike, and their tributaries will flow down valleys of denudation in the direction of the dip. But if there are large fissures in the strata the main streams generally flow through them, while the course of their tributaries is in the direction of the strike.

Those rivers whose course is over sandy rocks or chalk seldom or never overflow their banks, and when they do so they subside again quickly; but those that flow over clays, especially if their stream is sluggish, are very subject to floods, and, as the water is not able to sink, these floods often last for a considerable time. Sometimes a river may flow over a sandstone apparently sufficiently porous to prevent its flooding, and yet these appearances may be deceptive, the stratum of sandstone may be thin and underlaid by a clay, in which case the effect would be the same as if the river ran over the clay itself.

In the temperate zones, floods are caused by heavy rains, or the melting of snow, especially upon mountain ranges, and these floods are as variable in their recurrence and extent as the climate which produces them. In the torrid zone, on the contrary, the inundations occur with great regularity, for they are due to the periodical rains, which, in tropical countries, follow the change of the monsoon after the vernal equinox, and are thus dependent on the declination of the sun. For this reason the periodical floods of rivers in the southern hemisphere happen at opposite times to those in the northern. According to Humboldt the flood of the Orinoco is at its greatest height in August, while that of the Amazon, which is south of the equator, is in March.

Rivers that are flooded by the melting of the snow are most practicable in the spring and autumn. Those which flow from large lakes seldom overflow. The St. Lawrence, for instance, which drains a basin of 297,000 square geographical miles, maintains an almost perfectly equable flow in all seasons. The floods of the Lower Rhone arise from heavy rains falling in the valleys of the Côte d'Or and Jura mountains, which form the basin of the Saône.

The approach of a flood may often be known by the discoloration of the water, caused by the increased velocity of the current stirring up the bottom, and by the rain washing a greater supply of sediment into the river.

During the war in Spain a French officer was ordered to pass with his troops to the opposite side of the Cinca, a tributary of the Ebro. Not knowing that this river is subject to be suddenly swollen by the melting of the snow on the Pyrenees, he sent his advanced guard, consisting of five companies, across the river at night, intending to pass with his main body the next morning; but during the night the river had risen so much as to be impassable, and he had the mortification of seeing his advanced guard killed to a man by the guerillas without being able to render them the least assistance.

The power of rivers to move sand and gravel is often an important consideration in constructing military bridges. Detritus is brought down by rivers in two ways, first when small particles are mechanically suspended in the stream, and secondly by the friction of the water against the bottom rolling and pushing small pebbles and sand before it; but the first of these is of little importance, as far as military bridges are concerned, for they are generally only of a temporary character.

The velocity of a river is greater in the centre than at the sides, and greater on the surface than at the bottom, the water in these parts being kept back by friction, and the more the river winds the greater is this retardation. The mean velocity of a river is about four-fifths of the velocity of the surface.

A velocity at the bottom of three inches per second has been ascertained to be sufficient to tear up fine clay; six inches per second fine sand; twelve inches per second gravel the size of beans; and three feet per second stones the size of an egg. But this power of moving stones is greatly increased in countries where, during some part of the year, the cold is sufficiently intense to cause what is called ground ice to be formed. This is ice, which, for some unexplained reason, forms at the bottom of a stream, and by freezing round the stones tends to buoy them up, and allows them to be rolled along the bottom. Floods also, by increasing the velocity of the current, increase the pushing power of a river. The reconnoitring officer may estimate the power of a river to move detritus along its course by examining the pebbles and sand in its bed, distinguishing those that belong to the rock over which the river is flowing from those that have come from a distance, for, with very few exceptions, they must all have been brought down by the stream.

When a river falls into the sea its velocity is checked, and it consequently deposits a large part of the sediment which it had brought down: this, together with the sand and gravel that is pushed back into the mouth of the river by the flood tides, and heaped up there, forms what is called a bar across it. Most rivers have them, but their situation depends on a variety of local circumstances, which must be taken into account for each one separately.

A rapid river is generally able to keep its channel open; but, when it changes from rapid to slow, the detritus it contains in suspension is deposited, and it gradually fills up its bed; the pushing power is also reduced with the reduced velocity, and fords are formed. Thus most mountain streams have fords where they debouch into the plains; and a small river is often fordable at its confluence with another.

When any circumstance, such as a bridge, or a sudden bend in the

river, checks the velocity of the current, and hinders the movement of the gravel downwards, it tends to make a ford. For this reason in a winding river, fords are often found in the direction of the diagonal, joining two contiguous spits (fig. 8). Sir H. Douglas mentions that the Spanish army, with which he served, forded the Esla, in the campaign of 1812, without loss or difficulty, by taking advantage of this circumstance; and in the same manner he forded the Duero near Zamora, and several other formidable rivers.

A hard reef of rock will also often make a shallow across a river, there being deep water over the softer rocks; and in general fords are most likely to be found where the bed of the river is widest. As the sections of rivers at all sinuosities are irregular, they are not so likely to be fordable there as at the straight parts; and the bottom at curved parts is never firm throughout.

The nature of the rocks in the country through which the river flows, as well as the velocity and direction of the river, also influence the character of fords. In sandy countries, and where alluvial deposits are frequent, they may often be found suitable for infantry, but, on account of the yielding nature of the bottom, impracticable for cavalry or artillery.

Some rivers have permanent fords, others shifting ones, owing to their having a variable strength of current, which often cuts through a ford which had been previously formed. For this reason a river subject to floods is liable to have its fords destroyed, with the exception of those formed by harder reefs of rock. Sometimes however a flood may make a muddy ford passable, by covering it with gravel; or a decrease of velocity in the current may occasion a deposit of mud in a place that was before clean. The sudden destruction of fords is sometimes attended with very serious consequences: thus, on the 31st of August, 1813, Soult sent three divisions across the Bidassoa to raise the siege of St. Sebastian: a three hours' rain destroyed the fords by which the troops had passed, and they, having failed in their object, were obliged to fight their way back over the bridge at Bera.

In making a bridge the banks of the river should be firm, and not subject to land-slips; whether this is the case can generally be ascertained by examining their shape, composition, and structure.

The direction of a coast line often depends upon the direction, dip, and hardness of the strata. When they dip seaward, the abrading power of the waves on them is very small; but, when their edges are exposed, the loss is often great. Suppose that the diagram (fig. 9) represents a line of coast exposed to the north and west, and that the beds dip 45° north; then the resisting power to the waves will be great on the north coast, and will be the same along the whole line; this coast will therefore be nearly straight. But on the west side, where the edges of the strata are exposed, the waste will be greater; and, as they are certain to be of different degrees of hardness, many indentations will be formed. The reconnoitring officer would therefore look in this direction for harbours.

The uses of Geology to a staff-officer are so numerous, but so difficult to describe, that I think the best way will be to give you an example or two, to illustrate the way in which it can be employed. Suppose then that the route of an army lay up the valley of the Severn, between the

Malvern and Cotteswold hills. The structure of this valley is shown in the diagram (fig. 10). The geologist, on finding that the hills on the left were formed of highly-inclined Silurian schists, could confidently predict that the country on that side was mountainous and difficult; but seeing that the strata below him were horizontal, and that the same structure extended to the hills on his right, he would know that beyond their crest large table-lands existed without ever having seen them.

To take another case. Suppose the south-east of England to be a half-civilised country, without any good roads—as many countries are in which British troops have to operate—and suppose an expeditionary force to land at Romney, a geologist would see at once that it would be next to impossible to move an army over the clays of the Weald; but, on ascertaining that the hills on his right were chalk, he would know that he would there find a country that troops could not only move over, but manœuvre on, and would feel certain that this must continue for some distance.*

Again, how much has been said lately about using the chalk escarpment that surrounds London on three sides, and which has but few openings through it, as a line of defence for the capital.

These are some of the many benefits to be derived by military men from a knowledge of Geology; many others might be mentioned, such as the thickness and dip of the strata being often a valuable aid in judging heights and distances, or in showing which of two places has the command; but, in fact, so varied and so universal are its uses that it would be impossible to enumerate them all. It has been well said that "the acquisition of a new truth is equivalent to a new sense, enabling us now to perceive and recognise innumerable phenomena, which remain invisible or concealed to others;" and this new sense of Geology is continually pointing out to its possessor various facts, all more or less connected with a knowledge of the country that he is in, and therefore all more or less useful to him as a soldier.

Leaving now the practical applications of Geology to military science, I hope I may be allowed to say a few words about its indirect bearings. "As tennis," says Lord Bacon, in his Advancement of Learning, "is a game of no use in itself, but of great use in respect it maketh a quick eye, and a body ready to put itself into all postures; so in the mathematics, that use which is collateral and intervenient is no less worthy than that which is principal and intended;" and the same may be truly said of Geology. The mental discipline that a student receives from a study of the physical sciences, the love they excite of knowledge for its own sake, and the exercise they give his mind in grouping together facts of very different aspects, are of the utmost importance to all; while the habit of observing closely, the necessity of his observations being accurate, and the power of drawing conclusions proportional only to the evidence, are faculties that cannot be cultivated too highly by officers.

As an employment for leisure time Geology yields to none of the sciences, either in mental or bodily exercise. A practical knowledge of it can

* Since I read this lecture, I have been told that one of the questions at an examination in the Ecole Polytechnique, about two years ago, was, "What difficulties, geographical and geological, are presented by the coast of Sussex and Kent to a military landing?"

indeed only be obtained by dint of hard walking; while, on the other hand, Sir J. Herschel has pronounced that "Geology, in the magnitude and sublimity of the objects of which it treats, undoubtedly ranks in the scale of sciences next to astronomy." What these objects are is eloquently expressed by Professor Sedgwick, in his "Discourse on the Studies at the University of Cambridge." "By the discoveries," he says, "of a new science (the very name of which has been but a few years engrafted on our language) we learn that the manifestations of God's power on the earth have not been limited to the few thousand years of man's existence. The geologist tells us, by the clearest interpretation of the phenomena which his labours have brought to light, that our globe has been subject to vast physical revolutions. He counts his time not by celestial cycles but by an index he has found in the solid framework of the globe itself. He sees a long succession of monuments, each of which may have required a thousand ages for its elaboration. He arranges them in chronological order, observes in them the marks of skill and wisdom, and finds within them the tombs, of the ancient inhabitants of the earth. He finds strange and unlooked-for changes in the forms and fashions of organic life during each of the periods he thus contemplates. He traces these changes backwards through each successive era till he reaches a time when the monuments lose all symmetry, and the types of organic life are no longer seen. He has then entered on the dark age of Nature's history, and he closes the old chapter of her records." Surely no study could be more enticing than this; but it is as much to the immense variety of subjects connected with it as to the magnificence of its objects, that Geology owes its great charm. It is in fact the meeting point of zoology, botany, mineralogy, chemistry, and physics, each of which can be taken up as a separate branch, according to the inclination and opportunities of the student, while some or all of them may be pursued at every station in the world, and will render the dullest quarters pleasant and instructive.

With regard to collecting, although the specimens have certainly the disadvantage of great weight, yet this is in some measure counterbalanced by their imperishable nature; and Physical Geology, the branch which is most useful to soldiers, wants no collection at all, but requires only a hammer, compass, clinometer, note-book, and strong pair of boots.

As Geology is the most useful of all the sciences to a soldier, so is a soldier's profession the one of all others best adapted for its study. Remaining in one place sufficiently long to get well acquainted with its structure, and then moving to another perhaps far distant, and in a totally different formation, he has opportunities of studying Physical Geology which few can hope to possess, while at the same time he has ample leisure for reading and working indoors; and as in the course of his life he visits nearly all quarters of the globe, and sometimes goes into unknown, or but half-explored, countries, he may fairly hope to do good service to science, as well as have an inexhaustible source of occupation and enjoyment.

The study of Geology is greatly assisted by the two auxiliary sciences of Palæontology and Mineralogy, which bear somewhat the same relation to it that algebra and calculus do to mathematics; they are the means by which many of its problems are worked out. An extensive knowledge of

both is essential to any one who wishes to study the subject deeply, but for all practical military purposes a slight acquaintance with them is quite sufficient. To be able to distinguish the principal minerals of which rocks are composed; to have a general idea of the different forms of primary, secondary, and tertiary life on the earth (remembering that it is of more use to know the habits and mode of life of one common and characteristic form than to know the names only of fifty rare ones); and to have an eye so far educated as to be able to recognise similar fossils when found in different rocks is all that is required of the military geologist; for it is seldom of consequence to him of what age a rock may be, or to what formation it belongs, he only wants to be able to trace it out and so find it again in other places.

His attention should therefore be principally given to Physical Geology, the arrangement and structure of rocks, and the various ways in which they have been formed. Let him remember, that, although the elements of Geology may be learnt in the lecture room or from books, it is in the field alone, among the mountains, by the roadside cutting, or the sea-cliff, that he can learn to make any use of them. Let him take his hammer and his note-book, and go out into the country, and examine sections with his own eyes. Let him give up thinking that collecting fossils is the end and aim of all Geology; but let him endeavour to learn the dip, composition, and thickness of the strata, and the general structure of the district around him. Let him look for signs of denudation and metamorphic action, for faults and fissures. Let him consider how and when the hills, valleys, and plains were formed; and, above all, let him try to make a geological map of the country he is in, correcting it afterwards by the best one that he can procure. It is by studies like these that he will obtain a really practical and useful knowledge of Geology, and will not be in danger of mistaking cross-bedding * or cleavage for planes of stratification, and alluvium or wash † for rocks *in situ*. He will also find that he has acquired a new power, that will not only expand his mind and heighten his pleasure for scenery of every description, by enabling him to trace its history in its form, but one that will greatly aid him in nearly all his military duties.

List of books recommended—

Sir C. Lyell's Principles of Geology. Ninth edition. 1853. Murray, London.

Sir C. Lyell's Manual of Elementary Geology. Fifth edition. 1855. Murray, London.

Sir H. De la Beche's Geological Observer. Second edition. 1853. Longman, London.

J. B. Jukes's Student's Manual of Geology. Second Edition. 1862. A. and C. Black, Edinburgh.

J. B. Jukes's Popular Physical Geology. Reeve and Co., London. 1853.

D. T. Ansted's Elementary Course of Geology, Mineralogy, &c. Second edition. London. 1856.

J. Phillips's Treatise on Geology. Longman. London. 1852.

J. Phillips's Guide to Geology. Fourth Edition. Longman. London.

* When a stratum is made up of laminæ running in an oblique or waving direction. Also called false stratification.

† A term applied to the detritus of a rock that has been washed by rain to a lower level.

Friday, March 28th, 1862.

W. STIRLING LACON, Esq., in the Chair.

ON THE CAUSES OF SICKNESS IN THE ENGLISH WARS, AND ON THE MEANS OF PREVENTION.

By E. A. Parkes, M.D., F.R.S., Professor of Military Hygiene in the Army Medical School.

It is quite a truism to say that the great losses in war are not owing to shot or steel, but, like many other truisms, it is more often repeated than comprehended. Even to the mind of the soldier, the strife and peril of the battle-field throw into shade the more secret yet deadlier foes by which oftentimes campaigns are really decided and victories are really won. And yet, if there be anything a soldier ought to study out of his immediate profession, it should be those conditions which, in so many wars, have caused such losses by disease, that plans the best considered have been abandoned, courage the most heroic has been baffled, and causes the most sacred have been lost.

Our own army does not, perhaps, offer so many examples of these disasters as the armies of other states, but even with us there is a long and sad catalogue of unfortunate and unhappy enterprises, and a terrible list of soldiers' lives which have not been taken on the battle-field. As it is manifestly a matter of greater interest to review our own history than to turn to the larger and darker experience of other nations, I shall venture to attempt the enumeration of the chief causes which have led to great losses by disease in some of our wars. The subject is, however, too vast to be treated in a single lecture, and all I can venture to do is to give a rapid summary, and to illustrate it by a few examples.

As far as diseases are concerned, the history of almost all our wars presents a remarkable sameness. The same results on a larger or smaller scale repeat themselves. We are taught with what a terrible precision the same causes have stamped their marks on successive generations of soldiers, and how the pitiable history of one campaign might almost be stereotyped for nearly all the rest. Nor are these causes in any way peculiar, recondite, or mysterious. We are astonished to find how simple they are, how obvious, how apparently inadequate to produce such large results.

A writer, in giving an account of the great loss on one occasion among British troops, when, out of 7,000 men, 5,000 men were sick at one time, after enumerating the very simple conditions which had led to this end, says,—

"And yet when anxiously asked by the officers in command, what extraordinary cause could be assigned for an amount of sickness and

mortality truly alarming, something of incredulity has stolen over the countenances of my hearers while the natural causes above described were detailed, so little are we disposed to believe that great effects can be produced by the action of common causes."

But so it has always been. That the causes are common is the secret of their strength; they are ever at hand; even waiting, so to speak, for opportunities; apparently weak, they are in reality all-powerful; they are like the geni, who, in the story in the "Arabian Nights," the fisherman let out of the vase. At first there was a little cloud, which he could enclose with his hand, but presently there appeared a gigantic shape, clothed with power and irresistible in strength.

Of the early English wars the record is so imperfect that it would be waste of time to refer to them. Even of the wars of Marlborough we have but scanty medical accounts. We know that Marlborough had the reputation of being very careful of his wounded men, and it is said that he made a point of paying frequent visits to his hospitals. Doubtless he brought his extraordinary administrative powers to bear upon the medical, as on all other parts of his army. But of the exact losses by disease in his campaigns I believe little or nothing is known. They are supposed to have been small, as he was always able to bring a large number of men into the field, and England, at that time so comparatively thinly peopled, seems to have easily supported the drain both of men and money.*

Of the wars in Flanders and Germany in 1742, and of all subsequent wars, we possess tolerably good accounts, although the exact statistical reports and tables of our own day were quite unknown, and it is only from chance passages that we can form a rude numerical idea of the amount of sickness and mortality. The description of the diseases however, and of their causes, is for the most part both full and accurate.

1. Of the earlier expeditions after the wars of Marlborough, perhaps none was attended with greater losses, or excited more strongly the public feeling, than the unfortunate attack on Carthagena in 1741, under Vernon and Wentworth. It was not the first of the western tropical expeditions in which enormous losses had occurred, but the failure was so sudden and so overwhelming that it created an unprecedented sensation. To the military features of the campaign I need not refer; the dissensions between the commanders of the land and sea forces; the feeble movements of the general, and the vain courage of the troops, are sufficiently known.

Scarcely had the troops disembarked than sickness commenced. The diseases were malignant malarious fevers, scurvy, and bloody flux. The Spaniards looked down from their walls which they were scarcely called on to defend, watching curiously the dwindling away of their besiegers, till the rainy season of 1741 set in. The diseases then increased at a rate so fearful, that, to avoid complete annihilation, the force was hastily re-embarked. It is said that no less than 3,425 men perished in two days. In a few weeks, in fact, the army had been almost destroyed, and we are told that "its poor remains were afterwards almost totally cut up in the sickly season in the island of Cuba."

* The greatest losses appear to have occurred during the sieges, especially those of Tournay in 1709, and of Aire in 1710. In this latter siege the killed and wounded of the allies were said to be 7,000, and the sick double that number.

The causes of this tremendous catastrophe were matters of common talk and tradition among army surgeons for many years afterwards. Two grand errors were committed; errors which we must put in the first rank among those conditions from which British forces have largely suffered in war.

The first of these was that old error, a most imperfect commissariat. We are not acquainted with the exact rations issued at Carthagena, but the presence of scurvy, which prevailed both in the army and navy, but most in the former, proves at once that fresh meat and vegetables were entirely wanting. The scorbutic dysentery, which soon succeeded, shows us, as certainly as if the diet lists were before us, that hard salt beef and pork and biscuit formed the miserable allowance, scarcely deserving the name of food, which was issued to these men.

The effect of insufficient food of this kind is to cause some diseases ; to predispose to many more. It is in this last circumstance that its great strength lies; malarious fevers are intensified by it; slight atmospheric vicissitudes, and other common agencies which fall harmless on the well-nourished body, tell with fatal effects on the enfeebled frame.

In a great number of the English wars an inefficient commissariat has been the bane of the army: I will select two or three other instances of the same fact. Perhaps the expeditions to Burmah, in 1824, and to China, in 1840, offer the best examples. In both cases the scene of operation was to some extent malarious, and in Burmah the worst time of the year, at the commencement of the south-west monsoon, was unfortunately chosen for the commencement of operations. But in both cases the cause of the immense mortality which ensued, or at least by far the most potent cause, was the food which was issued to the men. In both cases it was thought that men could be maintained not only in health, but in fighting condition, upon a diet so bad that no slave-owner in any part of the world or in any age of the world would have given it to his slaves. Wretched cattle hastily purchased and driven to Calcutta were there as hastily salted, and on this wretched meat and on almost as wretched biscuit the troops were kept, when within a few days' sail there was a land of wheat, of rice, and of fresh vegetables without end. To the immense mortality in the Burmese war I need scarcely refer. In three or four months some of the regiments lost half their strength; in eleven months 1,311 men died out of 2,716. The 13th Foot lost by disease 341 out of 608 men, or 56 per cent. So general was scurvy that the surgeons were in the habit of examining the gums of the men before a skirmish, to prevent any men having symptoms of the disease from advancing, as wounds received in that condition of body are most intractable. Malignant malarious fever, intensified by the state of the body, and scorbutic dysentery were the great agents of destruction.

Twenty-six years later, in the expedition to China, the same tragedy was repeated almost without variation. The history of the Cameronians may be taken perhaps as a type of the fate of the whole force, although the amount of sickness was greater than that which prevailed in some other regiments. The Cameronians landed at Chusan, a splendid body of men, 900 strong, on the 5th of July, 1840; in the first week in August 500 were in hospital; towards the end of August less than 100 mustered

on parade; later in the season the *débris* of the regiment, under 200 men, were sent to Manilla to recruit, and of these but a fraction ever saw their colours again. The bloodiest battle would have been mockery to this. Doubtless they were to a certain extent in a malarious country, but the malaria was not sufficiently intense to cause so great a loss. Again the simple cause is to be found in the diet. Nothing lives so long as a departmental tradition, and the errors of the last naval expedition from India were repeated in this case without variation. I have selected these two campaigns as the strongest examples of the paramount influence of diet, but many other instances also exist in our wars of the effect of an insufficient commissariat. Even in such comparatively slight operations as the first two Caffre wars a large proportion of the men became scorbutic; and in the first year of the Crimean war a diet so insufficient that any one accustomed to the subject would have been able at once, on being informed of the amount, to foresee the inevitable result, was deemed sufficient to support the strength of the men in the most trying and exhausting of wars.

In the wars of Marlborough, and in Flanders and Germany in 1742 and in 1760, the men were better fed than in many later campaigns; salt meat seems happily to have been little used. The colonels of the regiments appear to have been the chief purveyors: each colonel contracted with butchers, who drove with the army herds both of sheep and oxen for slaughter. Fresh meat, at any rate, was thus procured, and we know from the writings of Donald Munro that in 1760 the army surgeons strongly insisted on the issue of bread and fresh vegetables; fruits also were largely used, and in this way the ravages of scurvy appear to have been almost prevented.

In the wars towards the end of the century and up to the long peace the commissariat arrangements appear to have been inferior to those of eighty or sixty years before. Some of the mortality in the Peninsular war may be certainly ascribed to an inefficiency in this respect. It would seem unnecessary to allude to a point so self-evident as this of insufficiency of food, did not the repetition of the error prove that it is one which must be expected to recur. The first rule in war must be to provide a diet in the highest degree strengthening and nutritious; the diet of peace is quite unequal to maintain the forces of the body when exhausted by the mental and physical exertions of war. It may seem an expensive matter to provide a diet which is sufficiently varied and sufficiently strengthening, but it is not so really. A great army surgeon has said "Economy of lives is the truest economy of the state," and no saving can be more like waste than the saving which sacrifices men's lives.

2. The second great error committed at Carthagena was undertaking operations in an unhealthy site and with an unhealthy season impending. Of course one can understand that a military officer, for the purpose of accomplishing some military end, may deliberately occupy an unhealthy site and knowingly sacrifice a certain number of men. There are examples of this in our wars; for example, in the attack on Java in 1811, when a marshy site was occupied at the outset; but even here the military arrangements were obliged to be somewhat modified and hastened in consequence of the rapidly increasing diseases among the

troops. But unfortunately there are many instances in which unhealthy sites have been chosen without any forethought, without any deliberation, and apparently either in the belief that men were made of iron and could not be injured, or that the stories of diseases being produced by locality were mere foolish inventions and old wives' tales. Although Vegetius tells us that the Romans, the great masters of the art of war, took the extremest care to choose good encamping grounds, and even appear to have made the plans of their campaigns subsidiary to this prime necessity, the point has been too much neglected in all modern wars, and even in the English army. Of the many examples of this I will select one or two only. In 1796 a body of troops about 9,000 strong were ordered to San Domingo; some of the regiments were collected from the West Indies and others from Ireland. The Irish regiments had been rather hastily recruited and typhus prevailed among the men, but it was thought that if time were allowed this disease would be got rid of; time, however, could not be given, and the expedition was launched against San Domingo. Now in 1780 Donald Munro, an army surgeon of reputation, had described with some care the unhealthy and the healthy places of San Domingo, and in 1793 portions of the island had been occupied by our troops. It can therefore be scarcely credited that the most unhealthy spot in the whole island, Port-au-Prince, was chosen for the encamping ground. There were not wanting those who supposed that the general had been deceived by persons interested in the choice of the site: be this as it may, the troops were crowded together on a low marshy alluvial plain, where good water could not be procured, which was shut out from the sea breezes by hills, and was completely exposed to the land-winds. As if this was not sufficient, the diet was bad, and salt meat without bread and fresh vegetables formed the staple of the food. With a view of increasing the strength of the body, an old custom of the English army was in full force, and the men received large rations of rum. Of all the errors committed in our service this seems to be the most persistent and the most ineradicable. Although the best army surgeons had at that time protested against the use of rum in hot climates, although in the American War of Independence the uselessness of rum had been proved almost immediately before, although at San Domingo the immense amount of sickness showed that it was producing no good result, the fatal practice was persevered in. That army had everything against it, and the result was certain; it was almost literally annihilated by yellow fever and dysentery. A writer who saw the sad catastrophe calls San Domingo "the grave of the British army," and says "The army languished and dwindled away without the least service to the cause it was meant to support." It is impossible to know the exact amount of the mortality. Many regiments 800 and 900 strong had only fifty or one hundred men left. All lost largely, and it is probable that few of that gallant force ever did the State more service.

The expedition to Walcheren gives perhaps a still better example of the effect of a marshy and malarious locality. In 1747 Sir John Pringle, one of the most celebrated in the long list of illustrious army surgeons, described the great unhealthiness of South Beveland and of Walcheren. So great was the sickness that in many corps 6-7ths of the men were in hospital at that time.

This low tract of ground, won in almost modern times from the sea, which is everywhere swampy, and where good water cannot be procured, had not lost its ancient and well-known reputation, when in 1809 the finest expedition that ever left the British shores landed in the highest health and vigour. They found there a Dutch regiment which in three years had lost 715 men out of 800: this was the type of their own fate. This great force, nearly 40,000 men in all, was destined to attack Antwerp; it never even approached that fortress. It sailed on the 28th of July from England, invested Flushing with 17,000 men on the 7th of August and took it on the 15th: twelve days later, the men were falling sick so rapidly that the guards had to be relieved twice daily. On the 14th of September, seven weeks after leaving England, out of the 15,000 men in Walcheren 10,000 were in hospital. The deaths at last reached sixty daily, at which rate the whole force would have been destroyed in 250 days. Four months after landing, the army, utterly disorganised, was hastily re-embarked. "The expedition"—to use the words of an eye-witness—"had been productive of nothing but mortification, misery, and disgrace." The diseases were malarious fever and dysentery.

Let me take another example on a smaller scale. In the American War of Independence, two battalions of the 71st Regiment were encamped, contrary to the advice of Robert Jackson, the prince of army surgeons, and of the inhabitants of the country, on the marshy banks of the Pedee river. The men fell sick so rapidly, that the post was ordered to be abandoned. It was then found that it was almost equally difficult either to keep or leave the post. At length, after a great deal of trouble, boats were collected, the sick men were placed in them and were sent down the river, and it is said that few of them were ever seen again. The rest of the force retired from the banks of the river, and, to show the deadly nature of the encamping ground, it was said that the men improved vastly in health even on the march.

The same mistake of a malarious locality being taken as an encampment, was seen in the second American War in 1814, at the siege of Fort Erie. And there are other instances too numerous to bring before you. Even the great Duke himself was said to have crippled his forces by a prolonged sojourn in the marshy plains of Estremadura.

As in the case of food, it may be said to be impossible that errors of this kind can occur again—that, with the present organisation of the service, before any campaign is undertaken the country will be investigated, its features known, and its influences estimated, and that the campaign will be entered upon with a full knowledge of all the circumstances which can affect the men. But we have unfortunately evidence that the immense influence of a malarious locality is not even now sufficiently appreciated by our soldiers. Under some circumstances indeed it is impossible but that campaigns must be undertaken in unhealthy localities and in marshy countries. In that case certain precautions must be adopted; these precautions have relation chiefly to the arrangements of the camps and bivouacs so as to shelter the men as much as possible from unhealthy emanations; to arrangements of guards, so as to expose the men, especially at certain hours of the night, as little as possible; to the use of an extremely nutritious diet, for that has been

found to have a great effect in lessening the susceptibility of the body to malaria; to the supply of good water, and to the employment of various drugs which have been proved to produce, more or less, immunity from attacks of malaria. If malarious countries are entered, and these and similar precautions are taken, the troops will escape with as little harm as can happen under the circumstances.

3. I must now pass on to another condition. The wars in Flanders in 1742 and in Germany in 1760 have been very carefully recorded; perhaps more so than any other war, with the exception of the Russian war of 1854-5. In both these wars, at certain periods, the men were exposed greatly to inclemencies of weather. It was then seen that if men are well fed and can be kept dry they can bear great cold. The winter of 1742 was extremely severe, and in April, when the troops commenced their march, there were extraordinary snows for seventeen days. The troops marched through these storms, but were every night received into warm houses. Out of the 16,000 men not twenty were lost. Again, in the German war in 1760, some regiments made a winter campaign on the borders of the Lower Rhine; they were exposed to great inclemencies of weather, to great hardships, and to extreme cold, yet they were very healthy, much more so than the troops left in the fixed camp at Warburg, who, it may be supposed, must have been in the possession of much greater comforts. This was owing to their good food and good clothing. At that time, 1760, every soldier wore a flannel waistcoat, a custom which has now unfortunately disappeared. This custom was commenced by gifts from the Quakers to the army in 1745-6, and it was found to be attended with the greatest possible benefit. In 1760 the Government issued warm clothing of this description, and in addition there was a very large private subscription in England, and blankets, great coats, under-clothing, shoes, stockings, &c., were given to the men. The men's blankets were carried on horses, and were wrapped in waterproof clothing. Each company had its own horses, which kept up with the men on the march.

The same fact, that men can bear great exposure to cold if properly fed and clothed, was also established in the American War of Independence. Some of the Rangers were out during the winter, and escaped almost entirely the diseases produced by cold. They attributed their immunity in a great measure to the use of hot ginger tea. Every man carried a piece of ginger in his pocket, and would on no account be without it. With this they made hot tea, and they found this much more comforting than spirits, which appear to have been in a great measure disused among them. Hot infusions of garlic and infusions of horseradish were also used for this purpose, until the more common employment of hot tea and coffee supplied us with means which may perhaps be considered even better adapted to protect the body against exposure to weather.

The same fact was again seen in the American War of 1814; in the partial winter campaign, the men bore the cold without great difficulty, being very carefully protected from the weather.

The same fact was again shown in the celebrated marches in Canada in the rebellion of 1837, and similar marches appear to have been repeated with as much success during the last few months.

Although, however, it appears to be quite certain that if men are well

fed, and if the surface of the body be kept thoroughly dry, they can bear great exposure, yet few armies have been so well cared for; and exposures to inclemencies of weather must be put down as the third cause which has been productive of disease in our campaigns. Even the campaigns of Flanders and Germany to which I have referred give many examples of this; one of the best, perhaps, is the often-quoted case of what occurred after the battle of Dettingen. Previously the men had been extremely healthy, after the battle they were exposed to wet and cold for two or three days; the consequence was that an attack of dysentery occurred, and was so general that half the army were affected; had this occurred a few days previously it is by no means improbable that the strenuous exertions which alone won the battle of Dettingen would have been impossible. So also in 1760 there was at times a considerable amount of sickness from exposure to weather, in spite of the great care which was taken of the men. In 1799 another campaign in Flanders owed its chief disasters to the inclemency of the weather, and the gallant force of the Duke of York was, in fact, beaten by the elements.

It is impossible that a general in command can ever protect his men perfectly from inclemency of weather; armies must be expected to suffer from this to a considerable extent; the diseases it produces are of course catarrhs, inflammation, rheumatism, and dysentery. But it is satisfactory to know what great effect the measures to which I have referred can have: if men are well fed and are well clothed and covered with waterproof clothing (which will probably be found the greatest boon which has ever been given to the soldier, but which is not yet sufficiently appreciated in our army), if hot liquids are provided for them, and spirits kept from them, or at any rate issued in the greatest moderation, there is no reason to think but that troops will bear a great deal of exposure to inclemencies of weather. Even the winter in the trenches before Sebastopol, had these means been available, might certainly have been met with comparatively little loss. But if from poverty or from defect of transport the warring nation cannot clothe and feed its troops, its plan of campaign must be adjusted to its circumstances, or it must be prepared to encounter a great mortality.

4. But catarrhs, slight dysentery, rheumatism, and inflammations are not the only diseases which affected the troops in the wars in 1742 and 1760; in both cases they suffered, though to a comparatively slight extent, from the spotted typhus and the putrid dysentery—diseases which have been the grand scourges of armies in temperate climates, in the same way as cholera and yellow fever have been the destructive agents in the tropical wars. The spotted typhus, the great typhus of armies, is, perhaps, the most terrible disease of all; wherever men are closely crowded together in ill-ventilated, unwholesome dwellings it is sure to appear. If scurvy be also present, it then attains its greatest intensity, and commits ravages which are truly astonishing. It has often passed from the army to the civil population, and has half dispeopled towns and even districts. Its ravages in the English army have never been comparable to those which have occurred in foreign forces, and, to give an idea of its powers, permit me to allude to a few examples of the effect of this disease among some continental troops.

In 1620 the Bavarian army in a few months lost in Bohemia not less than twenty thousand men from spotted typhus, and the disease being carried into other parts of Germany, obtained the name of "the Bohemian disease," just as, in the same way, on a later occasion, the typhus carried back from Hungary received the name of "the Hungarian disease." In 1628 and 1632 the Swedish army under Gustavus Adolphus carried typhus into Northern Germany, and the population was so destroyed that fifty or sixty years later villages remained without inhabitants. The wars of Louis XIV. were always followed by this disease, and the losses of the French army were enormous. But it was in the wars of 1812 and 1813 that its greatest ravages were seen. In May, 1812, the Bavarian army serving among the French numbered 28,000 men; in February, 1813, there were only 2,250 under arms. The great destroyer was typhus. In August, 1813, the first Prussian army consisted of 37,728 fighting men, in November of the same year it reached the Rhine with 11,515 men, having lost 16,000 men by the sword, and 10,000 men by disease, almost entirely typhus. Even this was trifling compared with the enormous losses among the French army. Not only the army but the civil population suffered fearfully. It is impossible to enumerate the hecatombs of victims; in Mayence alone the French lost in six months 17,000 men from typhus. It is impossible to overlook the effect which this must have had upon the fortunes of the campaign.

In later wars the same fact has occurred. I need scarcely refer to the great losses, even yet not perfectly known, of the Russian army in the Crimean War, and to the losses of the French army in the spring of 1856, when more than 17,000 men perished in less than three months, and when the highest authority stated that the safety of the whole French army was endangered by the outbreak. In the war in Flanders in 1742, and again in 1760, the great cause of the spread of typhus appeared to be the state of the hospitals. If typhus once enters a hospital, unless that hospital be extremely well adapted for the treatment of this disease, and if it once attains any proportions, it spreads among the patients with astonishing rapidity, and the hospital becomes a veritable pest-house. The only plan to adopt under these circumstances is that which was carried into effect by Sir James M'Grigor in the Peninsular War. Typhus had broken out in some of the hospitals; Sir James M'Grigor broke them up and distributed the sick among the villages, and in this way, in spite of bad food, in spite of bad attendance, and in spite of exposure, the disease was arrested. Anything indeed is better than a deficiency in the supply of air. There is no doubt that with proper sanitary precautions, the spotted typhus, terrible as it is, may be almost entirely put a stop to. It must, however, be considered as taking the fourth place in the causes which have produced disease in the British army.*

* Whether or not the circumstances to which I have referred, viz. great overcrowding and vitiation of air from organic impurities derived from respiration, will absolutely generate typhus *de novo*, is yet uncertain. In all the English wars, there has always been plenty of typhus-poison, waiting for favourable conditions to assume activity. This arose from the peculiar system of recruiting. Even in the Crimean War, we saw the relics of a system constantly resorted to in the last century to raise men. Commissions and commands of regiments used to be given to those who collected a certain number of men. Every low

It has never been absent from any considerable European war till the wise sanitary measures adopted in the Crimea showed us an army with scarcely a case, while two other armies under the same circumstances lost numbers of men.

5. The other disease to which I have referred, the putrid dysentery, is one which has prevailed to a still less extent, in the English army, than the spotted typhus. It prevailed to a certain amount in the wars of 1742 and 1760, and in the Peninsular War during a short time. Arising from various causes, from exposure to cold, from bad weather and bad food, it is also propagated by contagion, and appears, indeed, to give us an example of a disease acquiring contagious properties. This fact appears to have been first indicated clearly by Sir John Pringle, but it has been subsequently confirmed by a great number of observations in the French wars, and in other cases. As in the case of typhus, there is no reason to doubt that proper sanitary measures will lessen the spread of putrid dysentery. It must, however, I believe, take the fifth place among the diseases which have caused losses in the English wars.

6. I must now pass on to another condition, which possibly might have come before one or two of the others. In 1760 the head-quarters of the troops in the German war were at Paderborn in Westphalia. There was much sickness, and great dissatisfaction was expressed in England much in the same way as in the winter of 1854–5. The diseases were putrid dysentery to a slight extent, spotted typhus to a considerable extent, and other forms of fever, among which doubtless was the disease now known by the name of typhoid fever. These malignant fevers arose at the standing camp at Warburg, and were carried to Paderborn. They were produced by the condition of the camp, which had been inhabited for a very considerable time. Both it and the whole country around were covered with putrid remains. We are told that dead men and horses lay around in "infinite numbers," and that the bodies were only thinly covered by earth.

The unhealthiness of standing camps—unless the greatest care be taken to cleanse them—is one of the best known facts of army hygiene. The frequent shifting of encamping grounds is almost the only rule which has come down to us by means of which Alexander the Great so marvellously preserved the health of his men. The Romans also took the most special care for the cleanliness of their camping grounds, as indeed in all other matters connected with the health of their men.

Unfortunately, in modern armies the grand rule of paying the greatest attention to this duty has been too little regarded. In the English army it has perhaps been more attended to than in other armies, but even with us it is impossible to read the accounts (unfortunately too short) of the

purlieu, every infamous haunt, every jail even, used to be ransacked for recruits. Wherever these men went, they carried typhus, at that time the constant scourge of our towns and our jails. It gives one a strange idea of the making of a soldier, to read in Donald Monro's essay, published in 1764, a caution "that particular regard be paid to those soldiers picked up in the streets, or who have been taken out of the Savoy or other jails. All dirty rags from such people should be thrown away or burnt." Complaints of the introduction of typhus from this source are frequently found in the writings of army surgeons of the last century. Typhus was several times carried to the West Indies, and even prevailed there apparently to some extent.

camps even in the Peninsular War without perceiving what prolific sources of disease they were.

Let me take another instance of the effect of bad encamping grounds, as it illustrates one or two other points. In 1801 a force of 4,000 Europeans and 4,000 natives landed in Egypt from India. In June they commenced their march across the desert; they underwent hardships which Sir James M'Grigor thinks were never exceeded by any army. The heat was intense, the thermometer in the tents marked 118°, and at nine o'clock in the morning at three feet depth in the ground the thermometer marked no less than 69° Fahrenheit. Owing to the difficulty of carriage, no spirits were issued. In spite of all this the men were remarkably healthy, proving, what our Indian campaigns have also shown, that with proper precaution, and if spirits are avoided, great heat can be borne without risk. Having reached the Nile, the army descended that river for 400 miles, and landed at Ghiza. There they found the 89th Regiment very sickly; scarcely fifty men mustered on parade. This ought to have attracted attention, inasmuch as the 89th should have been considered to be the touchstone by which the sanitary condition of Ghiza was to be judged. However, the army was there disembarked, being then, to use the words of Sir James M'Grigor, "uncommonly healthy." In less than a week they sent into the hospital ten per cent. of their force; in three weeks there were a thousand sick out of the eight thousand men; in four weeks there were twelve hundred sick: then the army moved to Rosetta. We must therefore consider that no less than fifteen per cent. of that force had in that short space of time been in the hospital, and one-fourth of the duty-men in all probability must have passed through the hospital. The diseases produced in this short time were attended with very slight mortality; they were chiefly fevers which appear not to have been of malarious origin, but chiefly of that kind, yet little investigated or understood, which are known by the name of the bilious remittent, or the bilious typhoid, and the bilious relapsing fevers of the Mediterranean and Egypt. There were also slight dysenteries, and some ophthalmia, but no plague till afterwards, when the army got to Rosetta.

It was supposed at one time that the diseases produced at Ghiza were owing to the marshes in the neighbourhood, but this is rendered improbable; first from the fact that, as far as can be known from the accounts of the diseases, which are very short and imperfect, the malarious taint did not form any grand element in these diseases, and secondly from the following fact—Ghiza for months had been an encamping ground of a succession of bodies of troops—Turks, Mamelukes, French, and then English. The whole country was covered with putrid effluvia. At a subsequent period, when time had been given for the perfect dissipation and complete decomposition and elimination of all these putrid remains, Ghiza was again occupied and was found to be healthy; therefore it would appear certain that the condition of the camp was the cause which led to the great amount of sickness in the expeditionary force.

Filthy standing camps, then, giving rise to various forms of fever, typhoid being among the chief, and to other forms little understood, also to dysentery, and to cholera in some regions, must be put down as the next cause which has given rise to mortality in English wars. It is probable that this

cause will never again produce any great amount of sickness in our forces, inasmuch as not only is the necessity of the most perfect cleanliness in camps well understood, but in the present organization of the medical department, sanitary officers are appointed, whose special duty it is to insure the perfect and continued cleanliness of the camps.

7. I will now pass on to another head. The fatigues in war are excessive, and can only be borne by men whose frames are matured by age and constant physical exertion. Boys and immature young men are speedily destroyed, or only throng the hospitals. In campaigns every soldier ought at least to be twenty-one years old, and should have been accustomed to the most constant physical exertion and open-air exercise. Before a regiment goes on a campaign, it should be weeded of its immature men, who should form a corps of reserve, and be subjected to a thorough course of training, and be then sent on to join their regiment, when deemed fit to encounter the hardships of the campaign. The effect of exposing immature troops to the hardships of campaigns has been frequently illustrated. Some of the heaviest mortality in the Peninsular War was among regiments thus hastily recruited. In the Crimean War, during the second winter the troops were fortunately not called upon to undergo great exertion. Had they been so, in spite of all sanitary precautions, that young and untried army must necessarily have suffered very considerable mortality. Perhaps the best example in our annals of the effect of this cause is to be found in the history of the British Legion in Spain, in 1837, as given by Mr. Alcock. This body of men consisted of about 7,000 persons, hastily recruited, comprising Englishmen and Scotchmen, chiefly drawn from towns, and Irishmen who were more largely drawn from the open country. Almost all the force were either too young or too old. They landed in Spain during the winter. In the first few months after landing, one-third of the English, one-fifth of the Scotch, and one-eighth of the Irish were "rapidly swept into the hospitals." During the six months which succeeded their landing, they lost the "lives and services of 2,000 men," and the whole force was enfeebled and crippled for six months; no doubt they underwent very great hardships, were exposed to the weather, had bad food at some part of the time, and bad shelter; but they were not exposed to greater hardships than have often been met with little loss by seasoned troops. The great cause of their losses is to be found in the quality of the men, and it is worth observation how comparatively easily the Irishmen, drawn from the country and accustomed to open-air life and to the physical exertion of agriculture, bore the hardships which prostrated so rapidly the town recruits drawn from Scotland and England.

The often-quoted marches of Napoleon may be just alluded to here in reference to this point. In 1805 the so-called "Army of England" marched across France, a distance of 450 or 500 miles, with scarcely a straggler, and with scarcely any sick. In 1812 and 1813 the French army was an army of recruits, "boys who died by hundreds on the roadside." The Emperor bitterly complained, but his complaint met with no response. He had exhausted France by fifteen years of glory, and seasoned, hardened veterans were not procurable.

But even seasoned and veteran troops may be too highly taxed. Of this

there are not many examples in the history of English warfare. There are a considerable number in the history of continental armies, as in the army of Prussia in the time of Frederick the Great, and later.

Properly to train his men, to train them so that they shall be ready for great emergencies, to save them when saving is practicable, so that when necessary their whole strength may be called upon, must be one of the most striking powers of a great commander. The exposure, then, of immature young men to the hardships of war, hardships which must be undergone, must form the next series of causes which have given rise to disease in the English wars.

8. But now, supposing that the provident care of the Government and the skill of the general have succeeded in meeting all these conditions—have succeeded in providing well trained and seasoned men, in properly feeding them, in properly clothing them, and protecting them as far as can be done against inclemencies of the weather, in looking out for, anticipating, and providing for the causes which produce typhus, the causes which produce putrid dysentery, the causes which produce typhoid and other forms of fever—supposing that all this could be done, would an army be healthy?

In answer to this it may be said that it would be, that it must be, in a great measure, healthy. But there are still some causes which the soldier himself calls into action, and from which his officers can only in a very slight degree protect him. The agencies which the soldier himself thus calls into action are, especially, the want of cleanliness, which is so difficult to be enforced in war, the excessive use of spirits, and debauchery.

During any exertion it is an important matter to keep the skin perfectly clean. There are those who underrate the importance of this point, but they are mistaken. It is a point of prime necessity. Now in war such cleanliness is hardly possible to be enforced. Water cannot be procured, time perhaps cannot be given, and the soldier necessarily becomes extremely dirty. Hence there is a certain amount—no great amount, but a certain amount—of ill-health proceeding from this cause alone.

Whenever an army has been kept from spirits, although it has been placed otherwise under unfavourable conditions, its health has been good. Some striking examples of this may be taken from the American War of Independence, among the American troops. At first the American troops in the revolutionary war were unhealthy. After a time they ceased to be paid—funds were not forthcoming to pay them. They then became very much healthier—in fact extremely healthy. The same thing occurred in 1814. In that war the American troops were also unhealthy at first. They ceased to be paid, they ceased to purchase spirits, which previously they had indulged in, and again they became healthy. A surgeon who witnessed both these campaigns states, and very truly states, that "when the soldier is poor in money he abounds in health." The same effect of abstinence from spirits being attended with an improved state of health of the troops has been witnessed often in the English army. The case of the "illustrious" garrison of Jellahabad is a striking instance. Another most striking instance is given by Sir John Hall in the last Caffre war. The troops were exposed to great hardships and inclemency of weather, and yet remained extremely healthy, in consequence, mani-

festly, as appears from all the circumstances of the case, of the fact that spirits could not be issued to, or procured by them. But perhaps the most interesting example of this fact is to be found in the celebrated Cornwallis campaign of 1781, in which a body of men made a long and fatiguing march of more than 2,000 miles, were exposed fully to inclemencies of weather, were supplied by a commissariat which was rather indifferent, and yet remained extremely healthy. Dr. Chisholm, the surgeon of the 71st Highlanders, shall however narrate this case. I will read an extract from his book giving an account of this celebrated march. He calls it "the most remarkable campaign of the American Revolutionary War, owing to the dangers, fatigues, and privations sustained by the army in the course of it:"—

"They effected a march of nearly 2,000 miles through a poor country, inhabited by inveterate enemies, always more than 200 miles from their resources; forded many large, deep, and rapid rivers at the hazard of their lives; fought one pitched battle against thrice their number; were almost constantly engaged in skirmishes; were deprived of rum or any strong liquors; were for weeks successively reduced to the scanty support which a few heads of Indian corn, and a precarious very limited allowance of lean fresh beef afforded them; had no shelter from the inclemency of the weather, or the damps of the earth and night, but a single blanket and a few boughs of trees hastily put together in the form of wigwams. These hardships, fatigues, and privations they were enabled to support by the example shown them by their excellent and amiable commander; by the exercise of marching being alternated by rest every third day, when practicable; by parading in clean linen once every marching day and twice every halting day, being obliged to clean and bathe themselves every day; by the men being obliged to wash their shirts and waistcoats and pantaloons themselves; by a necessary abstinence from strong liquors; and, finally, by what may be considered as not the least cause, their pursuing, not flying from, an enemy. The regiment I was surgeon to, the 71st Highlanders, composed a part of this truly gallant army; they consisted of about 600 men, and the average number of their sick during this arduous service was about twenty-five, exclusive of wounded, and they were all trifling cases."

Now here the great immunity from sickness may be considered to be dependent,

1. Upon abstinence from liquors.
2. Upon the enforced cleanliness.
3. Upon the rest every third day.

The commissariat, though indifferent, was not extremely bad; the men had fresh meat, at any rate, and appear also to have had corn, and possibly other vegetables. Of these causes the abstinence from strong liquors must be put down as the most important. In the long catalogue of wars I have not been able to find a single instance in which the use of spirits has been proved to be useful, and there is a very large number in which it has been proved to be detrimental. There are only three ways of keeping men from the excessive use of spirits. The first is to supply them with good malt liquor, and with red wines which contain a small per-centage of alcohol. The supply of red wines of this kind was

formerly strongly urged by Sir Gilbert Blane, the celebrated naval surgeon. The use of these wines is not merely negative as a substitute for spirits, but also positive, for by their use a large number of salts, neutral and acid vegetable salts, are supplied to the body, which are of the highest importance to the nutrition of the system, and are themselves no mean antiscorbutics. The second mode of preventing men from getting spirits is of course by camp regulations. We have seen this attempted in the present American War, for a special Act has been passed by Congress for the purpose of hindering the men from purchasing spirits—a plan, however, which is always liable to considerable evasion. A third means by which men might be kept from the excessive use of spirits, would be to teach them how really ineffective and inoperative their use is in preventing them from suffering from diseases, and how many diseases the excessive, or indeed the even moderate, use of spirits may itself give rise to.

The third cause, which the soldier brings upon himself, and which has caused a great deal of sickness in some campaigns, has been debauchery. This, of course, is a point which can only be prevented, as far as it can be prevented, by camp and police regulations.

Such are the eight different and principal causes of mortality in our wars. I have arranged them in the order in which, looking over the history of English campaigns, I find they have produced the greatest amount of sickness. I have considered them separately or enumerated them separately for the sake of convenience, but in almost all campaigns two, or three, or four, or perhaps all of them, have been acting together.

There is no doubt that to a great extent these causes are preventible, but to prevent them would require that those in authority should fully recognise their existence and meet them with continued energy. To prevent them requires no special science, no peculiar appliances, but only the exercise of common sense and of knowledge which every soldier ought to have. The Romans certainly applied and acted upon rules which we must also apply, and acting upon them they appear to have escaped, at any rate to a considerable extent, those immense losses and tremendous catastrophes which have so often befallen modern armies. Their forces penetrated many countries and underwent many difficulties; the forest, the marsh, the desert, the cold mountain pass, the torrid plain, were traversed by them with impunity. Shall we, who boast a dominion as extensive and a knowledge more subtle and profound, fall short of the results obtained by those old masters of the world? If so, it will not be because our difficulties are greater, nor because our knowledge is less, but because we refuse to hearken to the lessons proclaimed to us from the camps and battle-fields of those thousands of British soldiers who in times gone by have fallen victims to the preventible diseases of campaigns. We must not suppose, because those lessons are so obvious, that they can be suffered to be forgotten. A writer whose name will assuredly be hereafter placed by the side of those of Robert Jackson and of Henry Marshall, says, "All errors should be treasured up in our memories. Although the past cannot be redeemed, it ought to suggest lessons for the future."

And Ranald Martin goes on to cite those memorable words of Samuel

Johnson, which, written in 1771, are still full of meaning, and have lost nothing of their truth and force.

"The life of a British soldier," wrote Johnson, "is ill represented by heroic fiction. War has means of destruction more formidable than the cannon and the sword. Of the thousands and tens of thousands that perished in our late contests with France and Spain, a very small part ever felt the stroke of an enemy. The rest languished in tents and ships, amidst damp and putrefactions, pale, torpid, spiritless, and helpless; gasping and groaning, unpitied among men, made obdurate by long continuance of helpless misery, and were at last whelmed in pits, or heaved into the ocean without notice, and without remembrance. By incommodious encampments and unwholesome stations, where courage is useless and enterprise impracticable, fleets are silently dispeopled and armies sluggishly melted away. Thus is a people gradually exhausted, for the most part with little effect. In this last war Havannah was taken, and at what expense is too well remembered. May my country be never cursed with such another conquest."

It is now ninety-three years since these memorable words were written, and it is only now that we may venture to hope that this country will not again be cursed with conquests that are scarcely less disastrous than defeats. Now at last an enlightened policy has been initiated, and the health of the soldier is, as Robert Jackson said it ought to be, "a primary consideration of the State." I venture to prophecy that in after times few reforms will be thought more important than that with which the names of Lord Herbert and Miss Nightingale, and others scarcely less distinguished, are now for ever connected; a reform in which the State both recognises a duty, and, as a reward, reaps an untold advantage. But it must be for the army at large and for the general public to support exertions which, without their aid, would languish and disappear. It must be for us, in fact, not to forget the teachings of the past, but to make them ever-living, that their warnings shall not be forgotten, and that their lessons shall not be unfruitful.

THE CHAIRMAN: I hope you will allow me to convey to Dr. Parkes your best thanks for his eloquent and most instructive lecture.

Friday, May 9th, 1862.

W. STIRLING LACON, Esq., in the Chair.

A NEW SYSTEM OF ARTILLERY FOR PROJECTING A GROUP OR CLUSTER OF SHOT.

By General O. Vandenburgh, N.Y.S.M.

For military purposes, gunnery has mainly had for its object, in its later attainments, the projection of a single shot, with increasing precision, range, and power, and, latterly, with especial efforts for augmenting the weight and magnitude of the matter, thus projected in a single mass. No argument is now required to show the value and importance of projecting a great shot, with great power and with great precision. There is, however, something besides the projection of a large single shot, which is equally legitimate as an attainment in gunnery, and of no less military importance. To uncover an enemy and penetrate his defences, it is necessary to concentrate the destroying power and matter in one body, in order to transfer it to one point. The object is to make that point vulnerable. When an enemy is uncovered, it is no less important to distribute the destroying force over the greatest possible area, compatible with the retention of a life-destroying efficiency at every point. Thus, if three 530-grain bullets could be projected simultaneously, one foot from each other, in the form of a triangle, with the same range and precision as a 12lb. shot, against an enemy in the open field, although the proportion of matter compared with the large shot, would be only as 1 to 57, they would yet cover and sweep a considerably larger area of space with a deadly and destroying force. The power it is true would be less within the space covered by the small shot, yet it would be sufficient. Neither one nor all of them could overcome so many obstacles in the line of flight; but when these obstacles are enemies, each has ample destructiveness. The large shot would do more effective work within the smaller area which it covers, but here again the smaller ones would furnish a compensation for this inferiority; for, while the large shot might go over, fall short, or pass through the enemy without effect, the same contingency must happen to all three of the small ones, which is not so likely, before they all cease to be effective.

The artillery now employed, attempts, and not without considerable success, the double duty of concentrating and distributing projectile matter, to meet the two conditions in which an enemy is found. It does this by the one operation of projecting the large shot which as a shrapnel, or segment shell, shall burst and distribute its fragments, either before or after it shall have done duty in penetrating a defence. The matter is united in one body for the purpose of projection, and then for field use there is an imperfect attempt to subdivide it.

If an imperfect performance of two duties from one mechanical organiza-

tion was better than a division and perfect performance by organizations best adapted to each, possibly the single-shotted gun might supply all military requirements. Brown Bess and smooth-bore field artillery each projected the single shot with considerable success before the rifled musket and rifled artillery were introduced.

The post horse, with no less considerable success, performed the duty of conveyance, doing a variety of double offices and conveniences, more than can now be remembered, which it was clear the locomotive could not, d' not, and never has supplied. The fact is, with new attainments with whi to compare former results, the latter often dwindle from what was great succe to obscure failure. Gunnery furnishes its own illustration of this in coi paring the old muskets and the new ones of to-day. The highest perform ance of the shell occurs when fired from rifled cannon. Being concussive or percussive, it penetrates defensive works as a solid body, and then by its disruption destroys not only such works, but the enemy within them.

The large single shell has here a high military duty to perform, where it has no competitor—of dislodging and uncovering an enemy, and forcing him from what is, on land, a negative condition of power, which has hitherto been, and must continue to be, inferior to the active, mobile, aggressive conditions of attack.

With the shell for field use, for disruption and distribution before meeting resistance, there is only the time fuse; requiring time, distance, and fuse to be accurately measured, and adapted to each other—a practical impossibility. Accordingly, we never know when or where the shell is to be converted into a group of shot; we never know the number or direction of the fragments. Until the bursting of this shell occurs, its efficiency is limited to a trio of small shot, and when the disruption does occur, its trajectory is substantially lost, and all precision and reliability of its action gone.

Assume an enemy to have a depth, vertically, on a plane, or any other surface of 10 feet, and let a shell be exploded into 200 fragments at any point within this enemy; let the fragments have a radial and forward direction, in a front hemisphere. Thus, theoretically perfect in the time, place, subdivision, and direction of the matter, it will be found that but 40 of these 200 parts can remain within the space occupied by the enemy, at the distance of 50 feet from the point of disruption, and at the distance of 100 feet, but 20.* Thus it must be apparent that the fragments of a shell of the same number and weight as the flying cluster cannot cover the hundredth part of the area, and surface, swept by the latter. If the shell has been found efficient in the field, it indicates in my judgment, not that it will be a competitor with the cluster, but the superior effect which may be anticipated from the latter. It must, I apprehend, be conceded, that the gun which will, with the highest efficiency and economy—terms which include everything—subdivide the largest quantity of matter into the greatest number of small deadly parts, and give the highest range and precision to each—the whole forming a group or cluster, best calculated to sweep and cover the ground of the enemy—that such a gun is most valuable for the field.

* This is on the assumption that the radial and projectile velocities are the same.—O.V.

Can we project, say, 163 small shot of the aggregate weight of the 12lb. shot or shell, or say 300 of the aggregate weight of the 20lb shell, under the same conditions as this single shot; that is, from a gun of no greater weight and dimensions, with equal facility for moving, the same ease and rapidity of discharge; these small shot to be solid or percussive shells, each to have a range and precision equal to that of the larger one, of which it is, in this view, a fragment, the whole to form a group, cluster, or swarm, to cover a large area, with a deadly force, *throughout the whole trajectory?* I answer, Yes, with the same ease, simplicity, and facility.

Assuming this answer to be correct, for one moment, before demonstrating it, such a gun may not present analogies which occur in comparing the new musket with the old one, or the locomotive with the horse. Yet, if we are to estimate the relative amount of work done in the same time, with the same physical or organic agents, neither shows a greater contrast than this new system of artillery, compared with that now in use.

We have observed that two modes of projection are theoretically and practically required to meet the two conditions of an enemy: one, the means to assail him when protected by defensive works, either on land or water, which the large single shot and shell gun furnishes; the other, to meet him when uncovered, in the condition of attack. The system which I now make public, is intended to meet the last-named requirement.

Of the comparative dignity and importance of the two systems best calculated to meet these two conditions, a few words may be said. As an enemy is most dangerous when uncovered and aggressive, so, for this reason, both the instinct and logic of man has assumed, the most efficient means of attacking him in this, his most formidable attitude as the highest means of attack and of defence. Indeed, we involuntarily look for the most deadly weapon by which men can destroy each other in the open field, and not without ample cause; for decisive struggles, on which national results depend, will be decided there.

It has been so in the past, it must be so in the future. Nations are not subdued until their country is penetrated, and the invader must be met, before he penetrates to the heart of an empire; thus, by a sort of natural necessity, compelling a proximate equality of naked condition in all great collisions, where an equal consciousness of strength animates both sides. And, whatever may be the conditions of naval warfare, or of coast defence, armies are not likely to march with iron plates before them.

I hope to present physical evidences to the senses, which are so much more potent than words, showing that a large shot, or in other words a large quantity of matter, may be subdivided, and thus simultaneously projected. Yet the senses cannot on this occasion ascertain that each one of these small parts will attain the range and precision of the larger projectile. The understanding can, however, be very well satisfied on this point.

To those who have considered the matter, it will not be new to hear that relatively small shot can be projected with a range and precision substantially the same as that of the relatively large shot. Such is the fact; not, it may be true, under precisely the same conditions, because the small shot can always obtain better conditions for projection than the large one. No doubt there are limits to the subdivision and reduction of projectile

matter (as there is in its aggregation) which, when passed, must impair its effectiveness in range and precision. For it is wholly improbable a fine pin or needle can be projected 9,680 or 10,000 yards by gunpowder. If the 530-grain bullet or even the ounce shot passes below that limit, in my judgment it has yet to be proved. It is not extreme distance of flight that I am considering, although that may be undetermined—it is lowness of trajectory—it is the attainment from an elevation under 10°—it is the range of accuracy, of what we call horizontal fire, which now lies within about 3,000 yards with the best rifled artillery. It is a remarkable fact in this connection both in artillery, and small arms, generally, that as the calibre has been decreased, the range of accuracy has been increased.

As great accuracy at long range has been obtained in this country as any where, from both the small and large shot.

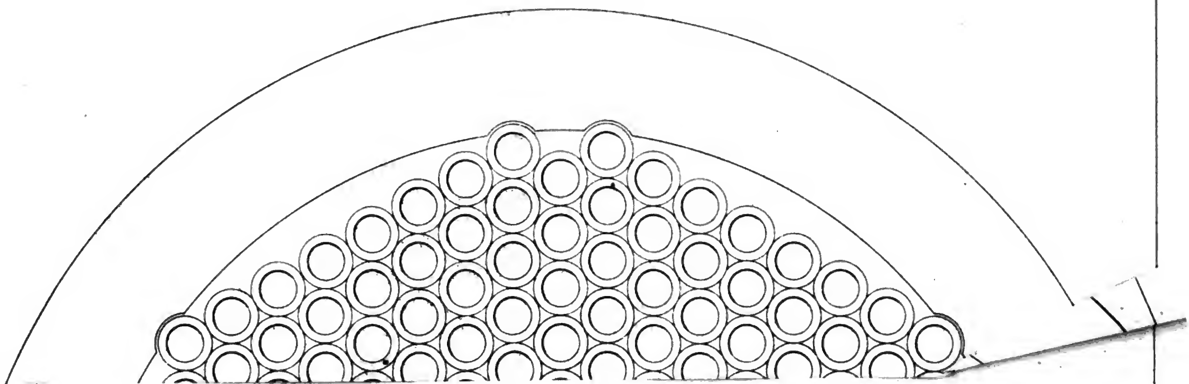
Of Government artillery the service 12-pounder is not surpassed by any larger calibre in these respects; it is the smallest from which I have seen reports. Passing to other makers of artillery, it will be remembered of the noted experiments of Mr. Whitworth, at Southport, with his guns of various calibres, up to an 80-pounder, the greatest accuracy and precision as well as the longest flight of the projectile, 9,680 yards, was from the smallest, a 3-pound projectile, 1½ inches in diameter. Another distinguished producer of artillery, Captain Blakely, has had I believe a like experience, with similar results. If the requirement from either of these three sources should be greatest accuracy at longest distance, I apprehend the calibre selected would be from below, rather than from above, any given standard now used.

To come to my own experience, I have obtained as great accuracy at extreme ranges from an inch calibre and a shot of 10½ ounces as I have seen recorded from the 12-pounder or any larger service gun. Then again I have obtained equally satisfactory results from the ·577 Enfield calibre, with a 2-ounce shot; this last shot, from this bore, giving as low a trajectory and as great precision, at any distance within 3,000 yards, as any service artillery I know of. With small arms we have the "small bore" supassing any of the larger bores which gun-makers produce; and comparing the largest and smallest shot now used for military purposes in this country, the elevation which gives 2,650 yards range to the 100-pound projectile gives 2,000 yards to the smallest shot, from the small-bore Whitworth rifle with 2½ drachms of powder.

Now while, as I have said, the small shot can obtain better conditions for projection than any larger one, it has yet, owing to its superior adaptability, been placed under limitations which the large shot has never been subjected to; these are, that it must submit to be discharged from a gun which a man can easily carry in his hand, with only about one half of its weight serving direct projectile purposes, and which the shoulder shall sustain when discharged. What but these limitations could make the small-bore ·451 superior to the ·577? If not limitations, there must be an inherent superiority of the small bore, and consequently of the small shot, over the larger one, which is more than I claim. By taking the Enfield bore out of a man's hand and away from his shoulder, thus allowing increased projectile matter, increased projectile power, and increased rotary velocity to be applied, it is not inferior to any calibre above,

GEN[l] VANDENBURGH'S SYSTEM.

Transverse Section of Gun, with Cluster of 265 Barrels.



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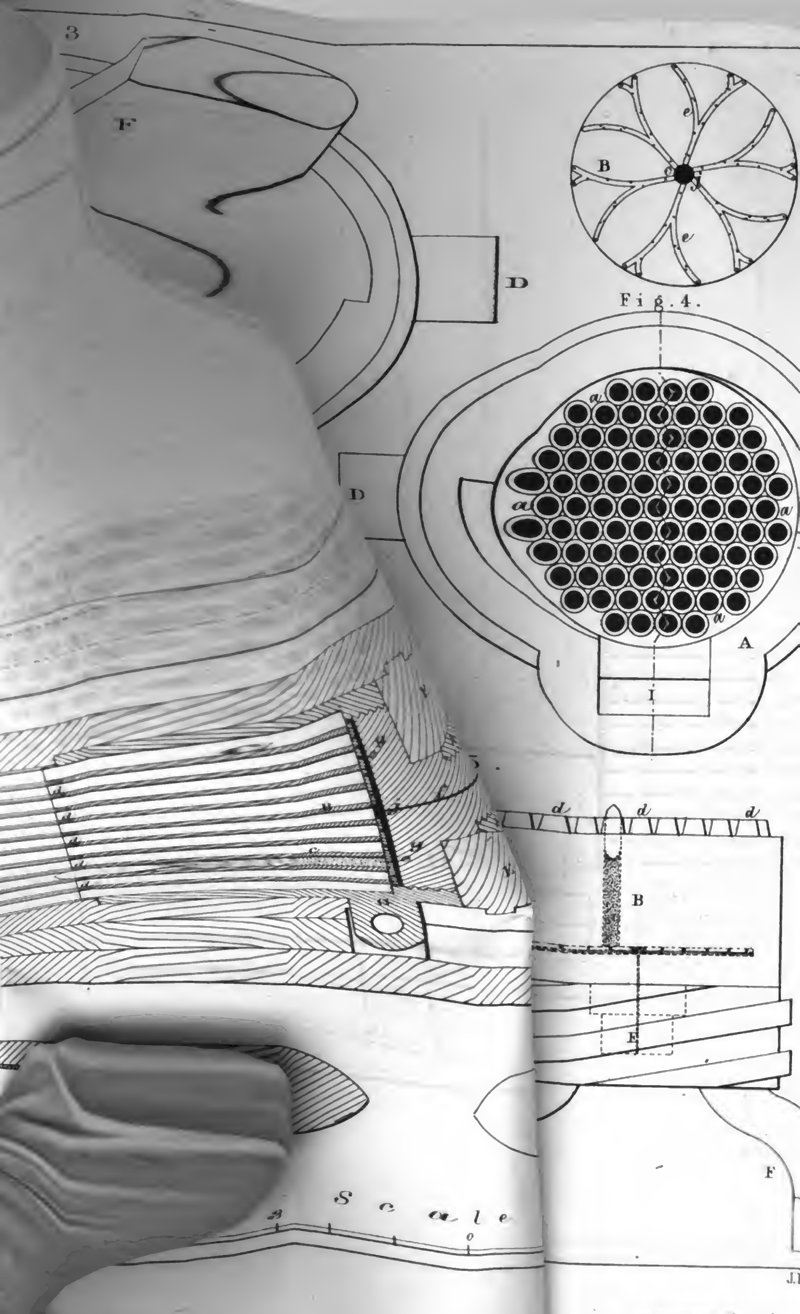
J.R.Jobbins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and greatly surpasses this one below it, in its present condition of use. And what reason is there to assume the ultimate result has been obtained, either from 530 grains of lead or the ·451 bore, in their connection in this musket? What has been obtained from it, has been under these conditions. Before this musket existed, there was the Government charge of 2½ drachms of powder, and of shot 530 grains, which a man stood under; there was the Government musket, with its general form and weight, which were satisfactory. With these, as I infer, arbitrary prescriptions, necessarily imposed it is true, the effort was to obtain the best results. In the combination of these it is a great success.

The Swiss obtain extraordinary results with less than half the weight of lead, and the same quantity of powder. It can hardly be supposed, with proper adaptations in the form of the projectile, and chase, 530 grains of lead can be projected no farther with 5, than with 2½, drachms of powder. All there is of projection, is power applied to, or absorbed by the projectile. No one can pretend the initial velocity of this shot, from this bore, with such a charge as a man can stand and fire, approaches to the ultimate velocity which may be imparted by the power of gunpowder to that weight of matter.

I have yet to make experiments with this small calibre, but you will see we are about to do so. As used it competes in range with the best rifled artillery, and, with these limitations, meets all but the exceptional requirements of the field.

Description of the New System.

The two accompanying illustrative plates will be found to thoroughly ucidate my system of artillery. Plate I. shows a transverse section of a ;un, with a cluster of 265 barrels.

Fig. 1, Plate II. represents a side elevation of an 85-barrelled "small bore" gun. Fig. 2, a longitudinal section of ditto. Fig. 3, is a breech, end view, with the breech closed. Fig. 4, is a similar view, with breech-piece and screw removed. Fig. 5. Vertical section of end of gun, with breech-piece carrying screw withdrawn, ready to receive charge. Fig. 6 shows ignition galleries chisel-channelled, with centre charge chamber coming through. Fig. 7. Full-size section showing charge chamber in connection with barrel. Figs. 8 and 9. Side elevation and section of powder charger. Fig. 10 shows full size 2 oz. shot, and 11 ditto with Gen. Jacob's percussive shell.

Throughout this Plate, similar letters refer to the same parts, A being the outside case; B, the breech-piece; C, cluster of barrels; D D, trunnions; E, breech screw; F F, handles for turning ditto; G, hinge attached to sliding bar, H, which moves backwards and forwards in recess I; *a a a*, bores of *b b*, barrels; *c c c*, charge chambers; *d*, short coned tubes set in ends of charge chambers entering breech-ends of barrels; *e e*, ignition galleries cut in a recess in back-face of breech-piece; *f*, vent orifice; *g g*, disc screwing in recess covering ignition galleries. This disc forms a fixed part of the breech-piece, and has a projection upon which the screw E turns; the nut *h* holding breech and screw together; *i*, muzzle plate; and *j*, central point of ignition.

No one but he who is devoted to an art, knows how very little is at any one time added in its progressive developement. Yet no one so well knows that progress is one of its conditions, gaining, as a general rule, step by step, seldom throwing aside as useless or rendering nugatory that which has been of advantage. Addition, he discovers to be the law of advancement, and the addition of a very little, sometimes produces great economies in both the arts of peace and war.

The normal developement of gunnery by this additional process is clear and distinct throughout its whole history to the present time.

In noticing only the latest substantive advancement, the addition of rotatory to the translatory motion of the projectile, it is observed that a high degree of perfection had been attained in the gun for projecting the round shot, from the smooth bore, before a basis was reached, in the form, structure, and material of the gun, for elongating the projectile, and adding rotatory to its direct motion. Nothing of previous attainment was lost, for the rifled not only utilizes, but imperiously exacts each principle, form, structure, and part, of the most perfect smooth-bore gun. This is one of the endless examples which all material progress exhibits of its rigid economy. Revolutionary abandonment and overthrowal of what has been gained, are rare phenomena, in the domains of physical advancement.

In the system of artillery now presented there is nothing new, except what may be embraced in the terms—*combination and addition.*

It is merely a combination of small arms, and artillery, into a distinct organization, giving, it is believed, advantages not possessed by either alone, at the same time preserving and giving free scope to all of realised science and art in gunnery.

The existence, and high developement, of both small arms and ordnance, was an essential precedent to its production.

If it be a normal growth of gunnery, as legitimate as any advance which has been made, and of no less importance, time and use will be sure to demonstrate it.

It is evident that to discharge any given number of shot in a cluster, and utilise the means for giving the highest range and precision to each, there must be employed a number of rifled bores, equal to the number of shot.

The mechanical difficulty of piercing a solid shaft or cylinder with orifices, compared with the cheap and almost perfect production of the single tube or gun-barrel, not only suggested, but practically forced, the adoption of the latter as the basis of the gun. To combine a number of these in a compact form so as to make a single body, to occupy no greater space and to be of no greater weight than the single bore, for projecting the same weight of metal, each to perform its office of projection as perfectly as if alone, was a work of considerable difficulty to attain, though surprisingly simple when accomplished. It was found, on placing a number of externally cylindrical tubes or gun-barrels together, the group was something like the honeycomb in structure with open triangular spaces between them. That each tube had six lines of external contact longitudinally against six surrounding tubes. This contact, even when pressed together, was only a line, scarcely so much as to be called space.

The spring or vibration of iron and steel barrels, when in contact, and

simultaneously discharged, is such as to destroy the range and precision of the shot. It was found, on experiment, that certain alloys of lead, with other metals, even common solder, completely answered the purpose of an *inelastic and deadening lining*, which, by occupying the spaces between the tubes, practically enveloped each although they were in contact (this contact, however, need not, and will not practically occur), with sufficient cohesion to solidify them into one solid body in connection with an outer metallic case in which they were placed. It was then found that not only did each tube perform as well as when singly and alone, but, owing to its being surrounded with this inelastic and incompressible material, with the six adjoining tubes forming so many perfect arches for its support, the barrel, though very thin, was incapable of disruption, and freer from vibration than when in the single gun with an excess of thickness. Each barrel was thus in a more perfect state for projection than has been hitherto practically realised.

In considering the comparative weight of the single barrel of large calibre, and many small ones of the same projectile capacity, it is now well known, (formerly it was doubted,) that the disrupting force of gunpowder increases from an increased quantity, in a higher ratio than the *additional law*, which regulates the quantity. Thus, while its quantity is increased by addition, the power for disruption is augmented by some unknown multiple ratio. So the resistance of iron, steel, or any substance, against this force, does not increase in proportion to its quantity, or, more strictly, it decreases as its thickness increases, because the resisting tenacity or capacity of the different layers of the metal cannot meet or resist the force at the same instant. Thus, it theoretically appears, and I have found it so in practice, with a given weight of metal to be projected, and of powder to project it, a less weight of material is required where the powder and shot are subdivided and projected through several barrels than when exploded and projected in one body through one barrel. I have dwelt upon relative weight because it is most important.

With reference to dimensions, there seems to be theoretically and practically no substantial variance between the group and the single bore; for, while the group has greater diameter and allows an application of the power to a greater sectional area of the projectile matter, there is a corresponding diminution in the length of the chase in the small calibre, so that in external dimensions the two systems are about alike when the outer case is added.

It will be seen, by the drawings exhibited, that the following number of gun-barrels in groups, each having the requisite thickness, can be contained in an outer case which is approximately a circular cylinder, the internal diameters of which are given, viz.:

Small bore ·451 calibre, 530 grains solid shot.

No. of Barrels.	Case, Internal Diameter.	Projectile Charge.
85	under 7 inches	lbs. 5·87
151	„ $9\frac{3}{16}$ „	„ 10·42
163	„ $9\frac{7}{8}$ „	„ 11·25
211	„ $11\frac{1}{4}$ „	„ 14·56
265	„ 12 „	„ 17·66
451	„ $15\frac{5}{8}$ „	„ 31·11

Enfield ·577 calibre, 2oz. solid shot.

No. of Barrels.	Case, Internal Diameter.	Projectile Charge.
85	under 8 $\frac{1}{8}$ inches	lbs. 10·62
151	,, 11 $\frac{3}{4}$,,	,, 18·87
163	,, 12 ,,	,, 20·37
211	,, 15 $\frac{1}{4}$,,	,, 26·37

The addition of the Case with trunnions, of from one to two and a half inches in thickness at the breech, decreasing to one-fourth of an inch at the muzzle, shows the full dimensions of the several guns, of different capacities.

Having thus obtained a group of barrels, which in weight, form, and facility of mobilising as a single body, will compare, in these respects, with the single bore of like capacity, the next step is, to prepare for charging, and discharging them, with equal facility and rapidity.

Breech-loading may have limits in its economy with the single shot, possibly very narrow limits; applied to the multi-barrelled gun, it surpasses the most sanguine anticipations of its projectors.

A solid block, or disc of metal, is bored with as many orifices, or chambers, in its front face, as there are barrels, each to hold the required quantity of powder for each shot, as well as the shot. They correspond to the group of bores, so that when this disc or Breech-Piece is brought against the breech-ends of the barrels, it gives a separate charge-chamber or breech to each.

If, in bringing this breech-piece against the barrels, or, in other words, the charge-chambers, in connection with the bores, this union should be in any degree imperfect, the escape of gas, or windage, from so great a number in such close proximity, would at once disrupt, or ultimately destroy the gun.

The revolving fire-arms of Colt, Adams, and others, it is true, show a chamber behind the barrel, dependent only upon the mechanical fit of two plane surfaces to stay windage; but here there is but one chamber, and the gas, if it escapes, passes harmlessly into the atmosphere. Again, with one barrel, a close mechanical fit can be obtained, while it is impossible to bring several hundred, against a plane surface, so that each, will equally fit, and press against it.

It was found if short thin Tubes of copper, brass, or steel (when of the latter material to be rolled in two thicknesses, like a strip of paper which has been coiled about the finger,) projected a short distance, say one-third or one-half an inch, from the powder-chambers in this breech, so as to enter a recess larger than the bore in the breech-end of the barrels, they formed tubular bridges over this joint or union, and the escape of gas was stopped. For, however loose is the fit of this tube in the barrel, if it is thin, or made of a coil so as to be elastic, the expanding gas in passing through, presses it outwards against the surrounding chamber, thus making for the time, when it is required, the most perfect mechanical fit. By making these short tubes conical, that is externally tapering, and thinner towards their projecting ends, it insures their easy and safe entry, and allows the breech-piece to be pushed, or brought home against the group, without the application of any considerable force to the breech-screw.

Here then is obtained a moveable breech, capable of receiving the powder and shot in separate charges, and when in position behind the group of barrels, and retained by a screw working behind it, making separate and perfect guns of each, as independent as if there was but one barrel and one breech-piece for it. Like the barrels, these chambers are in a single piece, to be manipulated with the same ease and facility as though it contained one charge chamber, which would hold the same quantity of charging material.

We now have bores and breeches, in which the highest proportion of powder may be applied to each shot; for this architecture of the honey-comb, and surrounding arches, extends to the breech-piece as well as the barrels, giving the greatest possible resistance to the quantity of metal employed.

For producing simultaneous ignition, it was observed that radiation was nature's process of distribution; that heat, and the gas from gunpowder, which contains it, are both imbued with a radiating tendency, as one of their primal laws of being.

A central point of ignition with galleries radiating from it, in the breech-piece, in the rear of the powder chambers, forming arteries or flues, and connected with the chambers, by no matter how small an orifice to each, was found to produce simultaneous ignition in an admirable, and nearly perfect, manner. Gunpowder, when confined so as to exert great force, has a tendency to remove obstructions, and, where there is a passage or vent, to open and not to close it. These passages do not receive the powder but only its gas, and require cleaning only at long intervals, and after hundreds of discharges. They are either bored with a drill in the solid rear of the breech-piece laterally or crosswise, or, which is preferable, cut in the form of channels with a chisel on the back face of the breech, and small orifices pierced from these channels to each chamber. This face is then covered with a flat disc which is brazed or screwed over them. While the latter process is most economical, it also allows curves to be introduced in the place of sharp angles at the various points of intersection, which angles are objectionable in the boring process.

The drawings exhibit the position of these galleries and the simple arrangement for easy access to them, when required.

A vent orifice, in the centre of the disc in the rear, leads to the centre of ignition and radiation, in which a friction-match may be inserted, or to which a lock and cap may be applied, thus again using the same arrangements for discharging the gun found most convenient with existing artillery. The centre charge chamber, if bored deeper than the others, will come down into and drop part of its powder charge in this focal centre of the ignition galleries. This is a convenient arrangement, as it supplies the ignition powder, without any priming or especially prepared match, to give the requisite gas for the galleries. The outer case, on which are the trunnions, extends in the form of a hollow cylinder to the rear of the barrels, for the reception of the breech-piece, and also so much further to the rear as to allow a screw or plate, turning on a pivot or boss projecting from the back side of the breech-piece, to screw into this hollow cylinder. This screw serves to open and close the breech and hold it in position during the discharge. There is a hinge joint which connects the lower side of the breech-

piece (when the gun is relatively small) to a sliding bar, working in a groove, in the under side of the case. When the breech is unscrewed it opens or falls back like the lid of a teapot, supported by this hinge and bar. The front face of the breech-piece is thus in a horizontal position with its charge chambers opening upwards ready to receive the charge. When the gun and breech-piece are relatively large and heavy, instead of one sliding bar at the bottom, there should be two, one at each side, and instead of a hinge the breech is attached by small pinions, so that it will swing or hang between them when unscrewed. Such is the gun. It consists of but three parts, not counting the hinge bar; with this, four; and when two of these, five. The outer case, with a female screw in its inner periphery at the breech end, its trunnions, its muzzle-plate, and its cluster of barrels solidified inside, forms *one*. The breech-piece, with its chambers and short tubes on its face, its galleries, and vent orifice, *two*. The screw, with two short handles working behind the breech-piece, *three*.

It may be noticed by the thin and extended circumference of the case at the breech, greater surface for the thread of the screw, and consequently greater strength, is afforded from the same weight of metal than in the single bore system. The screw can only receive a direct back pressure from the attempted recoil of the breech-piece, there being no lateral or bursting strain upon it, and it is wholly removed from the powder. Again, subdividing the powder gives less strain in this one direction, while the cutting or bursting effort of the gas for escape, is limited to its force in any single chamber.

Now, can the same principle of combination be used in introducing the powder and shot into the gun? I answer, Precisely the same.

The operation of charging is extremely simple, and performed as quickly as the charging of a musket. In all cases, the gun can be charged as rapidly as any single-shotted breech-loading guns projecting equal weights of metal. A charge, though made up of many parts, is handled as a single united body.

The same time and effort is required to empty a given quantity of powder out of one large measure, as from several hundred smaller measures, when the latter are connected together so as to be controlled by one act.

There is the same care and precision required to bring one bullet coincident to an orifice for insertion, as in bringing 200, when the latter are so arranged that, when one is in the right position all the others must be.

While a cartridge can be made for inserting the powder and shot together, conforming with the existing practice of putting in the powder at one operation and the shot by another, is considered, as at present, satisfactory.

For charging the powder, I use a Brass Flask with a flat bottom, of the same dimensions as the face of the breech. A slight rim or band around the bottom serves as a guide, so that it will always and instantly take a definite position when set on the breech-piece. It may conveniently hold but one whole charge, or 3, 5, 8, or 10, depending upon its upward extension, upon the capacity of the gun, and upon what may be found most convenient in this respect. The top is covered with a lid, so that a package of powder can be instantly put in and closed. The bottom is

pierced with orifices, corresponding to the charge chambers. Inside, there is a separate compartment over each of these orifices, each of which will contain a precisely measured charge, all alike. The powder in the flask is above these compartments.

Now, by the simplest possible arrangement of two plates with holes in them, one above and one below in the inside of this flask, controlled by two knobs or springs on the outside, and by merely touching these with the finger the compartments are instantly filled and instantly emptied. At any time, whether on the breech or when held in the hand, or in the act of setting it on the breech, the pressure of the finger opens the compartments above, and the powder falls in and fills them. By placing this flask upon the breech-piece and touching a spring, there is instantly deposited in each chamber a measured charge.

Whether the breech contains one chamber or 500, charging with powder, by this arrangement, will be the same both in time and manipulation. This charger is strong and compact; when the lid is closed it is a sealed case; neither wind nor weather, indeed neither water nor fire, unless from a shell striking it, can impair its use. In charging the shot, that form of projectile most perfect for projection is found most convenient. By loading at the breech, the shot are deposited in chambers slightly larger in diameter than the chase or bore. They thus take the rifling without being expanded, which in muzzle-loading is obtained by the flat end and hollow rear. An elongated projectile, conical at both ends, is used. These are set in orifices, in discs of common deal, corresponding to the chambers in the breech, with the usual paper patch around them. These orifices are slightly opened or countersunk on the underside of the disc, so that when placed on the breech, the ends of the short tubes will just enter each, and give it a definite position, with the orifices which contain the bullets directly over the chambers. When the shot are set up in these discs, melted beeswax and tallow is poured upon them; this in its fluid state surrounds the shot in the orifices, and in cooling, hardens and retains them in their places. They are now in the most perfect form and condition, cheaply packed in discs ready for use and transportation. If each shot contains one of General Jacob's percussive shells, they are by this arrangement handled and put in the gun with perfect safety, and I cannot see why they may not be securely stored and transported in this way.

To charge the shot, one of these discs is placed on the breech, and by the application of a flat board with projections, like the ends of ramrods, on its under side, about an inch in length, they are instantly pushed through on the top of the powder. More force but less time is required to push 100 to their places, than one through the barrel of a muzzle-loading rifle; as a ramrod with two points upon it can be carried one inch and back, quicker than one point can be carried 30 inches and back again. By taking hold of the handles of the screw, the breech is turned up and slid forward, when the screw catches in the case; one turn of the screw (one hand of a man has ample strength for this with a 12-pounder) and the gun is ready for the match.

Another convenient means of loading the shot is to put them in deal discs with their front ends at the bottom, the orifices in which they are set not being pierced through the board. In this case they are not

fastened by the lubricating material, but set loosely. A mahogany or other hard wood board and a brass plate fastened to it, with holes through them, corresponding to the cluster and breech, is all that is now required as a bullet charger.

A spring keeps the brass plate with its lands or solid parts under the orifices in the board, so that the shot cannot pass through. This charger is set on the disc containing the bullets and turned over when they fall into the holes in the charge-board. It is now placed on the breech; guides give it the right position; when, by touching the spring, the holes in the brass plate are brought coincident to those containing the shot, and the latter instantly fall through into the breech.

My experience as to the divergence of the shot, or density of the cluster when discharged is this:—Commencing first with a 37-barrelled gun, bores one inch in diameter, set parallel, shot 10½ oz. each. The gun is under 900lbs. in weight, capacity over a 20-pounder. The arrangements connected with the breech were less perfect owing to the early stage of the invention, than those now exhibited. I may say its power and endurance were surprising. The only injury I could inflict upon the barrels from any weight of charge occurred at the muzzle, where, from the rapidity of twist in the rifling, extreme length 50 inches, and high velocity of the projectile, high charges had a tendency to tear out the bores towards the muzzle. The mechanical defects or want of perfect parallelism in the bores gave the shot a divergence of some 25 feet in 400 yards; at 200 yards, the divergence was only half this, and at 800 yards, twice as much, and so on to any distance, which I could ascertain and measure. And this is a condition of the system, a diverging cluster increasing in proportion to the distance, and plan of divergence adopted in the structure of the gun. Where the group exceeds 150, I apprehend a slight divergence or opening of the barrels at the muzzle either horizontally or vertically, or both, will be desirable. In a gun of 91 barrels, Enfield ·577 bore, set parallel, I find about the same divergence in the shot as that just described. Thus, at 100 yards nine-tenths of the shot will be placed in a target six feet square, though it takes a target nine feet square to take them all at this distance, owing to the greater divergence of a few. At double this distance they occupy twice the space, and so up to a mile when they cover substantially about 100 feet. When only one-half or one-third of the group in this 91-barrelled gun are discharged they yet give about the same divergence, so that I infer when the barrels are set parallel, the mechanical defects do not increase the spread of the shot, when there are a great number, more than when there are but few. Theoretically this would be so, and I have found it so in practice. It would follow when a gun projected 200 or 300 shot, there would be a great density even at an extreme range of 2,500 yards, if set parallel. At 1,200 or 1,500 yards they would cover a breadth of 65 or 75 ft. so effectually that not a man could live on the ground swept by such a cloud of shot.

For a handy field gun, 150 of the "small bores" can be made to come under 600 lbs. in weight; its capacity will be 10½ lbs of shot. Recoil, by the sub-division of powder and shot is reduced to meet this reduction in weight.

I can see no cause why these guns will not stand the wear of service as

well as any others. A small rifled shot wears the chase less, and a small charge of powder eats out a breech-chamber less than when the shot and powder are increased.

The only parts which can be considered delicate and liable to injury by use, are the short coned tubes on the face of the breech. These from the manner of charging cannot well be injured; but, assume it to happen, they cost about two pence each, are set in smooth recesses of very little depth, and, while it is impossible for them to be blown out, they can be instantly pulled out with an instrument if injured, and new ones replaced.

The limits assigned to this paper preclude a comparison of the effectiveness of a given number of shot, projected by a gun on this system, and by the same number of riflemen. I think it can be demonstrated that those from this gun would be by far the most efficient, owing to the great concentration of fire, certainty of aim, and greatly extended range. The various military uses to which these guns may be applied, as well as the advantages I attach to a group of shot, the divergence of which increases with the distance, must from the same cause be left unnoticed.

NOTE.—The latter part of the foregoing paper, descriptive of the system of construction, was delivered without written notes. The breech-parts of two guns, from a 91-barrelled, Enfield calibre, and an 85-barrelled small bore, were exhibited with wooden models and diagrams to explain their construction.

A reference to one feature of construction was accidentally omitted. It is hoped it will not be considered irregular to add it here.

By a simple arrangement, these guns may be discharged by sections of one-sixth, one-third, or one-half of the group, the other sections remaining charged, ready to be fired instantly, or at any interval of time afterwards.

It will be observed the ignition-galleries in any group, however numerous, are but six, as they commence divergence from the centre. By putting a cut-off or stopcock across each of these passages, which, by turning in one direction, will open, and in the opposite close the passage, the gun can be discharged by sections.

With a 30-pounder naval gun, projecting 450 shot, it may be very desirable at times to discharge it in sections of 75 each, in rapid succession.

I have practically tested such a cut-off, and find it can be successfully worked.—O. V.

The CHAIRMAN:—It is not customary at our afternoon lectures to raise any discussions, but this is a most important subject, and, as General Vandenburgh is a stranger, it will probably forward the object we have in view if any gentleman would put any question which would elicit additional information.

Captain BLAKELY: I think that there is no question remaining to be answered, General Vandenburgh has been so lucid in his explanations. If, however, I am not out of order, I should like to express an opinion on the matter. In the first place I will begin with a point in which I cannot go quite so far as General Vandenburgh. That is, with respect to the relative range and accuracy of some of the large guns. I think the larger they are, the more accurate they are. But I do not think that at all detracts from what I perceive to be the great merit of this system, though it will not be applicable for a range of 10,000 yards, yet I believe that up to 2,000, even to 2,500 yards, this system as developed by General Vandenburgh will be effective; indeed, I believe he will be able to carry the largest canister firing up to fully 3,000 yards. We know that General Jacob made very good practice from the shoulder as far as 2,000 yards with a single rifle bullet. Now to fire from a steady rest a cluster of bullets of that kind directed against a battery of artillery at two or three thousand yards must, I conceive, be most mischievous to the battery. At a shorter range perhaps the ordinary canister will compete with it; but for intermediate

ranges, between 500 and 2,000 yards, I can conceive nothing much more deadly. There is one application of it which General Vandenburgh did not dwell upon, and that is against iron-clad ships. Even supposing General Vandenburgh does not overcome the difficulty of loading, which by some simple arrangement so far as I can see he has overcome, yet were that difficulty of loading still to exist, guns of this kind can be loaded at leisure, taken up alongside within range of the iron-clad vessel and fired at least once or twice at the port-holes. I can conceive the possibility of at least two or three port-holes being entered by the bullets, and the certainty of one or two men at each port-hole being killed; and I fancy that would be very much more mischievous to iron-plated ships than even the penetration of one 300-pounder shot. One 300-pounder shot will not stop a ship, and will at most only do very little damage, whereas firing from this gun if continued would really stop a ship.

Captain Burgess: What would be the weight of one of these guns with the cluster of 85 barrels?

General Vandenburgh: This gun will weigh about 400lb. The quantity of matter it projects, 85 shots, would weigh something like 6lb. The weight of the gun will be under 400lb; it would depend very much upon how much the outer case was turned down. I find I have over-estimated the strength required. Here is a drawing of a gun (showing it). I do not know that it will ever be made, but I think I could make it entirely successful to discharge 451 of these small shot. I am more and more convinced that these small shot will meet all the requirements of the field. Here is a 20-pounder gun, for 163 shot of two ounces each ·577 bore. The weight of this gun will be 1,200 lb.

Captain Burgess: Do you suppose that if a 12-pounder shot were to strike that gun, the blow would interfere very much with the barrels?

General Vandenburgh: I do not know what gun would stand being hit a great many times with solid shot.

Captain Burgess: I mean if struck by a single shot.

General Vandenburgh: I think it would injure it. The gun is more vulnerable than existing artillery, less vulnerable than a musket. I do not think it would be worth much after being struck by a 12-pounder shot.

Captain Burgess: Might it not be obviated by a casing of wrought iron?

General Vandenburgh: I do not think we have any field-guns that are invulnerable. If they are once hit, or knocked off the gun-carriage, they are worthless for that battle.

Captain Burgess: The question I ask is, whether, if a shot struck it and bent some of the barrels, it would be useless afterwards.

General Vandenburgh: I admit that to be so.

The Chairman: The casing will be iron?

General Vandenburgh: Gun-metal casing; however it can be made of forged iron or steel. I find gun-metal, as it can be cast in the requisite shape, can be used most conveniently.

The Chairman: It only devolves upon me to convey to General Vandenburgh our thanks for the very lucid account he has given us of this gun.

Evening Meeting.

Monday, April 7th, 1862.

CAPTAIN R. COLLINSON, R.N., C.B., in the Chair.

Names of Members who joined the Institution between the 17th February and 7th April, 1862.

Life.

Haworth, R. B., Lt.-Col. 22d East York Art. Volunteers, 9*l*.
Jones, O., Capt. R.N. 9*l*.
Marshall, W., Dep.-Lt. Cumb. M.P. 9*l*.
Poore, R. Major 8th Hussars, 9*l*.
Stirling, C., Comr. R.N. 9*l*.

Annual.

Adams, C. Major, Professor R.M. Coll. 1*l*.
Campbell, C. A. Comr. R.N.
Campbell, W. M. T. Lieut. R.E. 1*l*.
Childs, J., Capt. 4th Midx. Rifle Vols. 1*l*.
Chisholm, A. B., Lt. 1st Batt. 25th Reg. 1*l*.
Corballis, J. B., Lt. 1st Batt. 10th Reg. 1*l*.
De Wahl, T. A., Comr. R.N. 1*l*.
Doherty, D. H., Lieut. 3rd Hussars, 1*l*.
Falls, J., Paymr. 2nd Batt. 8th King's.
Fitzgerald, H.L., Cap. 2 Bat. 13th Lt. In. 1*l*.
Forbes, F. C., Lieut. 37th Regt. 1*l*.
Fox, M., Comr. R.N. 1*l*.
Gardner, G. H., Capt. R.N. 1*l*.
George, C., Master R.N. 1*l*.
Hartman, G. A. Cap. 2 Bat. 13th Lt. Inf. 1*l*.
Mann, W. A., Major late Kent. Mil. 1*l*.
Philips, G., Lieut. 2d Batt. 2d Queen's, 1*l*.
Peto, W. L., Major 2d Bat. 13th Lt. Inf. 1*l*.
Pennefather, R. P., Lt. H.M. Mad. Eng. 1*l*.
Russell, L., Capt. H.M. Beng. Eng. 1*l*.
Rowcroft, H. C., Lt. H.M. Beng. Eng.
Rawlins, S. W. Lieut. 8th Hussars, 1*l*.
St.Clair, C. W. Major 57th Regt. 1*l*.
Sitwell, H. C., Lt. H.M. 5th Ben. Lt. Cav. 1*l*.
Smith, A. C., Capt. 1st Batt. 25th Regt. 1*l*.
Sotheby, F. E., Capt. Rifle Brigade, 1*l*.
Trousdell, W. G., Surgeon 2nd Batt. 13th Lt. Inf. 1*l*.
Whitla, W., Lieut. 1st Batt. 10th Regt. 1*l*.
Young, C. F., Major R.A. 1*l*.

ON THE DISEMBARCATION OF TROOPS.

By CAPTAIN W. R. MENDS, R.N., C.B.,

DIRECTOR OF TRANSPORTS.

BEFORE I enter upon the subject standing on the paper in my name for this evening, I must ask the indulgence of the meeting for a few moments whilst I endeavour to explain how it is, that, for the first time in my life, I find myself in the position of lecturer, and before so critical an audience. It being generally known that I am the officer who drew up the arrangements for conveying to, and disembarking the British expeditionary army on, the shores of the Crimea, as well as for the subsequent minor operations at

Kertch and Kinburn, I have at various times been appealed to for some of the details connected with those undertakings, in order that the experiences then gained might be turned to account. In 1858, at the request of the officer who was entrusted with the task of compiling the engineering data of the Crimean operations by the Topographical Department of the War Office, I furnished a paper of the programme, a copy of which is on the table.

About five months since I was again appealed to by a brother officer to read a paper at this Institution on "The Disembarcation of Troops," as the subject was deemed important. To deny its importance was impossible, and that I should deliver a lecture upon it seemed equally impossible; therefore, on the moment, I declined to undertake it; notwithstanding which, I am here to-night to claim your indulgent hearing of nothing abstruse, theoretical, or amusing, but merely a few facts and opinions, the result of personal experience, in the hope that they may prove so far useful as to call attention to an important professional subject.

I adopt as my motto a quotation from Cicero—

"Qui mari potitur eum rerum potiri;"

which is translated thus :—"Whoever is master of the sea will possess the empire." And Bacon comments upon this as follows:—"But thus much is certain, that he that commands the sea is at great liberty, and may take as much or as little of the war as he will; whereas those that be strongest by land are many times nevertheless in great straits. Surely at this day, with us of Europe, the 'vantage ground of strength at sea (which is one of the principal dowries of this kingdom of Great Britain) is great."

England will do well if she lay to heart in 1862 those remarkable sentences.

My subject then being the disembarcation of troops, I set out with the belief I entertain, that to a great military nation possessing supremacy at sea belongs the power of successfully landing a large army on the shores of any other nation with which she may be at war, and that on the sea alone can an attempt at invasion be frustrated.

In support of this assertion, I purpose first directing your attention to some of the remarkable expeditions recorded in history, coming down to those nearer to, and in connection with, our own times. Secondly, I shall make a few remarks on the disembarcation of an army, showing on what contingencies we must depend for the success of the operation. Thirdly, I shall speak of the duties of the seaman towards the soldier when embarked. Fourthly, I shall put before you the elements composing an army, with a few observations on each. Fifthly, I shall direct your attention to the necessity for adapting the vessel to the arm of the service she has to carry, or, *vice versâ*, the arm to the vessel, with a view to rapid disembarcation; also to the description of boat or raft for commodious, safe, and expeditious landing. And, lastly, I shall give the details in connection with an imaginary landing of an army.

Ancient history tells us of many combined naval and military operations, some of them of so gigantic a character, in point of number of men, as compared with those of modern times, that we are almost apt to question the veracity of the historian. For the conduct of those expeditions by sea (however short the distance), the arrangements must have

been very perfect or they would have broken down under the pressure of mere numbers.

The expedition of the Argonauts, undertaken 1263 B.C., was of an important character, carried across that capricious Black Sea which absorbed the attention of the world in 1854 A.D. We read that "this was the first great enterprise of the Greeks. This is supposed to have been both a military and mercantile adventure, and was singularly bold for the times in which it was undertaken. The armament consisted of many ships, of which Argo was the largest, equal to a modern vessel of 200 tons burthen. The astronomer Chiron directed the plan of the voyage;" which I take to mean that the seamen of those days wisely looked to Chiron, as we in this age should look to Fitzroy, to whom the merchant and seamen owe a vast debt of gratitude, which will probably be more largely acknowledged by the next generation.

"481 B.C. Xerxes' army, after crossing the Hellespont, numbered 1,700,000 infantry and 82,000 cavalry. In the fleet were 1,027 ships of war and 3,000 galleys of three banks, having on board 517,600 persons." The passage of such a host across such a stream as the Hellespont required great administrative and practical ability. Further, we read that with 1,200 ships he attacked 380 Greek ships in the Bay of Salamis, and on being defeated Xerxes fled with precipitation across the Hellespont, as I conclude his supplies were cut off.

The expeditions of Alexander the Great are without end: 334 B.C. he crossed the Hellespont with 30,000 foot and 5,000 horse, encountered on the banks of the Granicus the Persian army of 100,000 foot and 10,000 horse, and defeated them. The operation of crossing must have been expeditious and precise, the result alone of good arrangement. Alexander's admiral, Nearchus, must have possessed infinite ability and nautical skill in the conduct of his fleet, embarking, disembarking, and supplying armies in the Indian seas.

The successful invasion of Britain by Julius Cæsar 54 B.C., and again by William of Normandy in 1066 A.D., were well-executed operations, showing great nautical skill and arrangement.

We read, in a paper by Professor Airey, of the former, "that 600 ships adapted to beach-landing were built expressly for this expedition, 28 long ships and numerous merchant vessels, so that 800 ships were in sight at once, carrying five legions, or 21,000 foot and 2,000 cavalry, besides camp followers and sailors, probably 40,000 souls in all." This flotilla was floated off at a single tide from some port of France. I conclude the characteristics of the British Channel have not much changed.

The same author tells us that William floated at one tide 1,400 ships, carrying 60,000 men.

The Spanish Armada, which threatened this country, was defeated at sea by a comparatively small but gallant force, the elements certainly proving adverse to Spain.

In the year 1647 the Dutch Fleet, with but 4,000 troops on board, alarmed the whole coast of France, and by it obliged the French king to keep near 100,000 men upon the maritime coast, as not knowing what point they would fix on. A state of things to which the following

quotation from Dryden's satire, entitled Absalom and Ahitophel, seems appropriate:—

> As when a battling storm, engender'd high,
> By winds upheld, hangs hov'ring in the sky,
> Is gaz'd upon by ev'ry trembling swain,
> This for his vineyard fears, and that his grain;
> For blooming plants, and flowers new opening, these,
> For lambs yean'd lately, and for lab'ring bees:
> To guard his stock each to the gods does call,
> Uncertain when the fire-charg'd clouds will fall;
> E'en so the doubtful nations watch his arms,
> With terror each expecting his alarms.

It may be said that we should not and cannot well compare the expeditions of bygone days with those of the present age; but I confess I do not see why. In my opinion, invasions or disembarcations are as practicable now as they ever were; indeed, navigation has been simplified by the aid of steam, and operations proportionally accelerated. An insular nation like our own should never permit a hostile force to reach her shores.

Look at the remarkable and successful landing of troops at Cape Breton in 1758 under Admiral Boscawen and General Amherst. We read in "The Conquest of Canada," by that charming writer Warburton, the graphic description of that operation, as follows:—

"Equipments were carried on in England with vigorous zeal, and on the 19th February, 1758, a magnificent armament sailed from Portsmouth for the Acadian peninsula. It reached Halifax on the 28th May. [three-and-a-half months at sea! Imagine the horror-stricken mind of the present day at such a voyage.] 22 ships of the line, 15 frigates, 120 smaller vessels, sailed under the Admiral's flag, carrying 11,600 troops, including artillery and engineers, almost exclusively British regulars. The troops were told off in three brigades of nearly equal strength under Brigadiers Whitmore, Lawrence, and Wolfe.

"At dawn, on the 2nd June, the armament arrived off Cape Breton, where the greatest part of the fleet came to anchor in the open roadstead of Gabarus Bay."

It was evident that celerity and precision were the order of the day, accompanied by complete preparation and organisation; for mark what follows:—

"Amherst, the General, hoped to land before daylight and surprise the garrison of Louisburg; and, with that view, orders were issued to forbid the slightest noise, or the exhibition of any light, on board the transports near the shore; the troops were especially warned to preserve profound silence as they landed. But the elements rendered these judicious orders of no avail. Morning came with a dense fog and heavy Atlantic swell, which broke in impassable surf on the beach. This lasted for six successive days, during which the enemy toiled night and day to strengthen their position ALONG THE BEACH, and lost no apportunity of firing upon and shelling the ships. On the 8th the swell partially subsided, and the naval officer, Commodore Durell, pronounced the beach practicable. The troops were placed in the boats before daybreak; the inshore covering ships opened fire to clear the way; in a quarter-of-an-hour the boats pushed on, the left under Wolfe, the right and centre under Whitmore and Lawrence. The left division was the first to reach the beach. The French stood firm

and held their fire until the assailants were close inshore; then, as the boats rose on the dangerous surf, they poured in a rattling volley from every gun and musket that would bear. Many were struck down, but not a shot returned. Wolfe's flagstaff was shivered by a bar-shot, and many boats were badly damaged; still the sailors forced their way through the surging waves, and in a very few minutes the whole division was ashore, and the enemy driven from their entrenchments. The victors pushed on, making 70 prisoners, until the guns of Louisburg checked their advance. In the meantime the remaining British divisions had landed, but not without losing 100 boats and many men from the increasing violence of the sea. For two more days no artillery could be landed. On the 11th the weather began to clear and progress was made. Hitherto the troops had suffered much for want of provisions and tents. On the 26th Louisburg surrendered."

I can scarcely quote a stronger example in proof of my belief that it is always in the power of a great and gallant people, with God's help, possessing command of the highway the sea, to conduct a flotilla and land troops on a hostile shore in safety. The resistance offered was gallant,—the characteristic of French troops.

The landing of Wolfe at Quebec in the subsequent year sounds almost like a romance.

The landing in Egypt under Admiral Lord Keith and Sir Ralph Abercromby is another striking case.

"On the day of arrival in Aboukir Bay, too much time elapsed before all were at an anchor to allow of the disembarcation being accomplished before night. For six successive days, northerly gales with a heavy sea prevented the operation. At 2 a.m. the troops began embarking in the boats, numbering 320. At 3 a.m. the signal was made to rendezvous near a brig of war at anchor, at gun-shot distance from the shore; but so great was the range or extent of the anchorage, that it was not until 9 a.m. the signal could be made for the boats to advance towards the shore." Thus the men must have been nearly eight hours cramped up in the boats before they reached the beach, during which time, in these days, aided by steam, an army of 30,000 men, including artillery and cavalry, could be landed.

We read—"The force opposed to them consisted of 7000 * French troops, with fifteen pieces of artillery in position, commanding the whole space of disembarcation, and others with field-pieces and mortars in different excellent positions which the ground afforded.

"A fire of grape and musketry from behind sand-hills seemed to threaten the boats with destruction, while the castle of Aboukir maintained a constant and harassing fire on their right flank. Nevertheless the beach was arrived at, a footing obtained, and the enemy forced back from all his

* Royal Hospital, Chelsea,
MY DEAR ADMIRAL, March 27, 1862.

As you seemed desirous to know the strength of the contending armies in Egypt (at Alexandria) in 1801, I wrote to a friend of mine at the Horse Guards, and he informed me that the French had 16,000 fighting men, and that John Bull had only 11,000. So that, in the hope that this bit of information may be useful to your lecturing friend, I send it to you. Believe me, very truly yours,

J. MORILLYON WILSON,
A "Middy" of the Olden Time.

positions. The boats returned without delay for the second division, and before the evening of the 9th the whole army was landed."

What was done in 1801 can be done in 1862, with this difference, that with the aid of steam we ought to be able now to do in one hour what occupied many then.

"Buonaparte, availing himself of the perfect organization of a mighty empire, maintained an enormous army for some time on the barren ground above Boulogne." His preparations for invading this country were in themselve complete: *he wanted but one thing,—the command of the Channel.* Models of the boats and flats constructed under his direction may now be seen in the Museum of Artillery in Paris, and in the Model Room at Toulon. Who can say what might have been the result had he been able to land a large army on our shores; or, had he lived in this age of steam, to what his ambition might not have led him if the sea were for a moment left open?

The landing of the French in Algeria in 1838, and the capture of that stronghold, is another case in point.

The last example I shall quote, is that of the expedition to the Crimea in 1854, though I cannot pass unnoticed the very last expedition to China, under Vice-Admiral Sir James Hope and General Sir Hope Grant, it appears to have been an operation so perfectly and completely executed.

The British portion of the expedition to the Crimea consisted of 120 sail, including 10 ships of the line (two of them being screw steamers), 4 frigates (one of them being a screw steamer), 11 steamers of war (paddle and screw), 24 steam transports including three of Her Majesty's, 7 steam-tugs (a most valuable adjunct), and 64 sailing transports.

The British ships of war, with two or three exceptions, carried no troops; thus were they in the proud position of convoying squadron to the allied forces, all the French and Turkish ships of war being full of troops and *matériel* of war, because they had not such a transport fleet at their command.

The force (British) to be disembarked, consisted—

30,000 Infantry	54 guns	1624	horses for	guns.
2,192 Artillery		1530	,,	Cavalry.
1,240 Cavalry		65	,,	Staff.
		160	,,	Regimental Staff.
33,452 men		3349	horses.	

Number of boats employed in landing men . .	326
Number of horse and gun flats	24

The allied flotilla when at sea numbered somewhere about 400 sail, and, as many of the ships were propelled by steam power, it was humorously said that Manchester had got adrift in the Black Sea, a remark that unwittingly reflected credit on the compact order of the transport fleet.

Arrangements were complete for landing at each trip 6,400 infantry, 12 guns, 216 artillery horses, and all the horses of the staff. It was decided by the late Lord Raglan not to land the engineers or cavalry until the whole of the infantry and artillery had been disembarked. At 7 a.m.

when the operation commenced, the water was smooth as glass; no enemy appeared to oppose the landing. As the ships were taking up position only one Russian officer with his mounted orderly appeared on the beach, and remained beside his horse for a considerable time, apparently occupied with his note-book, as though he were dotting down our proceedings, certainly neither contemplating a descent upon his shore, nor a departure from the rules of chivalry in the receipt of a warning shot. Suddenly our design seemed to burst upon his mind, and he beat a very hasty retreat, narrowly escaping capture, for the landing of the French troops further to the eastward had not been noticed.

By 6 p.m. 30,000 infantry and 24 guns, or four complete batteries, were landed: but sunset came upon us with a louring sky and a threatening swell breaking on the beach, a sure indication of approaching wind, rendering the disembarcation of artillery more and more tedious and difficult. At nightfall the weather was so bad, and sea heavy, that the operation had to be suspended. The troops had landed with three days' provisions in their havresacks, but without tents or camp equipage of any kind. Thus was that gallant army exposed for two days and nights on a hostile shore with no water except what fell from the heavens, not half its artillery, no shelter, and in the vicinity of a powerful enemy. There were ample grounds for anxiety on the part of the military chief; but the late Lord Raglan, who was by nature calm, knew that he was relying on the characteristic endurance and gallantry of British soldiers, and that at that moment he had under his command the flower of England's chivalry, therefore, when communication was again open between the fleet and the shore, not a murmur fell upon the ear. The cheerful and successful advance of the line has been elsewhere graphically described.

The foregoing examples strengthen my belief in the assertion with which I set out. In past times it has been seen that our own country has been twice successfully invaded and brought into subjection to a foreign yoke; and, if the sea be ever held in possession by a great military power hostile to England, there is no reason whatever why a powerful army should not again be landed in safety on her shores in spite of brick and mortar. I have heard a statesman put it thus :—"We cannot suppose for one moment that any foreign force could hold England; they might land and burn a coast town or two; but what would be the effect upon the world until England should be avenged for such an insult ?"

Prevention is surely better than cure, and, whilst the highway to England is over the sea, there, and there only, is the place to defeat such an object. With the aid of steam an unopposed landing may be almost guaranteed; so many feints can be made, so many distractions practised, that a defending force on the shore would be harassed and worn out with fatigue, whilst the invader would land fresh. Even though an opposing force presented itself at the beach, it would be difficult for the men to maintain position in the face of a powerful covering artillery; but unless the sea were clear no wise man, however ambitious, would attempt to cross it for the purpose of invading a country. We well knew that Sebastopol was one of the strongest existing fortresses, likely to be heroically defended, as was proved by the expenditure of blood and

money in its reduction, but it certainly never entered my head that we could not convey and land an army safely on the shores of the Crimea; and the truth has been told, that the chief anxiety of the allied naval commanders-in-chief was an attack by the Russian fleet whilst at sea, not an opposed landing at the beach. Conceive a flotilla of crowded ships attacked in transit by an active naval force; destruction would be certain, and very feeble the resistance. In all the operations I have quoted, beyond the fact of their accomplishment, we have few details to aid the practical officer in preparing for such an undertaking. And, when I carry my mind back to that of 1854, I am more than ever sensible of the unpreparedness of the practical mind to grapple with them, and our lack of the proper appliances to ensure rapidity and precision. When we looked upon the vast amount of war *matériel* landing at Varna, with the necessity for keeping up supplies for an army, it was not to be wondered at that grave anxieties and doubts should exist in the minds of many men, after thirty years of peace, as to our powers afloat to convey such a force and land it successfully.

I now come to the second branch of my subject, viz., the points to be considered to ensure the success of such an operation as the landing of troops. The disembarcation of troops may be considered in three ways:—

1st. From transports in one of our own snug harbours, lying alongside a pier.

2nd. On a foreign shore, hostile to us, but offering no opposition, as in the Crimea.

3rd. On a shore in the face of an enemy.

In any of these cases celerity and precision should mark the operation, and these are only to be attained by careful arrangement. In the first, the disposition of the ship at the pier-side; the fitting and fixing of a commodious brow or broad passage-way of planking from the ship to the shore, where it should terminate in a clear space, so that the troops as they walk out can be formed and marched off without delay, care being taken that the sides of the brow be secured against accident by strong stancheons and side-ropes, and, if its angle of inclination be considerable, that cross-battens be nailed across it to prevent slipping; fatigue parties and guards being told off to land the baggage, &c. &c.

2nd and 3rd. If the landing is to be effected on a foreign shore, the strength of the force must be considered with a view to that likely to be opposed to it after they shall have landed; the beach or part of the coast must be well selected; the depth of water in close proximity to the beach, and the sort of beach, well ascertained; the ships to form the flotilla arranged and adapted to each arm, with a view to rapid disembarcation; the sailing and anchoring directions clear and explicit; the means for landing the force well and amply provided; the convoying or protecting fleet told off; the pivot and covering ships well instructed and in clever hands, for the execution of the operation with precision specially rests upon them; the direction of the wind, the barometrical indications, the rise and fall of tide; the instructions well understood by men as well as the officers; and finally, the heart to undertake it.

Thirdly. The duties of the seaman towards the soldier when embarked. I do not think I am claiming too much for the profession to which I

belong, when I say, that in every instance the operation of landing becomes the pivot upon which all subsequent moves depend. I may go further, and say that not one of the great military operations in which our arms have been borne with so much honour and glory by the sister service, could have been entered upon without the aid of the seaman. Our insular position renders this an axiom. The importance, therefore, of the subject to the naval officer cannot be over-rated; not only should he endeavour, as far as in him lies, to ensure a successful landing, but, by the care of the soldier when embarked, he should do his best to land him in an efficient condition for the ulterior work he has to go through. It behoves us, then, to begin at the beginning, and study well the requirements to ensure both.

The naval and military services being with us a matter of choice by the individuals composing them (and may we never depart from so wholesome a system), it is assumed that each person selects that for which he thinks himself by nature best qualified, carefully avoiding the characteristics of the other, or that to which he is in his nature opposed. It is therefore assumed that the soldier at sea or on shipboard is there solely in fulfilment of duty, and in opposition to his feelings and inclinations. It becomes, then, the special duty of the seaman to make such arrangements as will ensure to him the fullest amount of comfort, consistent with good discipline, when embarked, in order to his being landed in the same high physical condition as he was when he was received on board. The sanitary condition of the ship is, therefore, of the first consideration, and well-defined regulations under this head are in force under the orders of the Admiralty. The practical seaman understands the meaning of sweet bilges, clean holds, roomy well-ventilated 'tween-decks, good capacious hatchways, with independent trunkways to the lower from the upper decks, to ensure good ventilation. For these arrangements, the fitting of emigrant ships which have come under my observation is worthy of imitation for long voyages; though all ages of both sexes embark in them, the scale of mortality is small. The regulations of the Admiralty for the transport of troops appear to embrace every important point bearing on the welfare of the soldier. I need not do more than call attention to them.

I now come to the fourth branch of my subject, viz., the elements composing an army.

When we have considered and massed them, we shall have a better idea of the requirements necessary to a rapid disembarcation. To begin with the infantry soldier equipped for service in the field and ready to be landed. Is he not a living fortress of a most formidable character? Added to his rifle and sixty rounds of ammunition, he carries in his havresack provisions for three days; his supply of water; his blanket, great coat, pack of necessaries, being spare clothing, and camp-kettle, or cooking-pot. I have seen the French soldier carry, in addition to the foregoing, the *tentes d'abri*, considered by them valuable in hot climates on out-post duty; bundles of firewood slung to their waist-belts; and being more provident, as well as less scrupulous, beings than the British, two or three live tortoises, fowls, or ducks This man, so armed and equipped then, cannot be moved about in a boat after the manner of the unfettered seaman;

he must be allotted a sufficient standing-space in the boat that conveys him, and an easy passage from the boat to the shore, dry-shod if possible, and with dry ammunition. It would be as well to call in question the courage or endurance of the soldiers of Sparta as of Britain; but I have seen the very men who would have jumped into the sea up to their necks had an enemy appeared on the beach, show a strong disinclination to wet their feet when there was no opposing force, and, much to the vexation of their officers, accept the readily and cheerfully proffered shoulders of the seamen for a dry passage, it being no easy matter for the man equipped as I have described him to be, to get his boots off. Who will say that the disinclination was not prompted by common sense? who amongst us, after crossing a stream in an ordinary day's walk, has not experienced inconvenience, discomfort, and a galled heel from wet foot-gear, from which he was glad to seek relief in an immediate change on his arrival at home, where a good dinner and fireside awaited him? Common sense tells the soldier to avoid the evil if he can, as he has no such luxuries to look forward to: he may probably have a march before him; a battle to fight; a lie-out in the open for a couple of days or so on scanty rations in a pestiferous climate. Under such circumstances a sore foot ensues, which probably ulcerates if the man has been long on salt provisions, and he is compelled to fall out to seek the surgeon's attention: if this happen but to one per cent. of the force, see the embarrassment it causes the chief. I have made these remarks with a view to direct attention to the importance of details in their utmost minuteness when dealing with the arrangements for landing troops on a beach. In few words, it behoves the seaman not only to give his heart to the matter, but his best ability.

Thus much for the single soldier of infantry equipped for service; if we multiply the unit by 1000, we have the average strength of a regiment. Add to this number of men five horses for the regimental staff, two horses for the surgeon's implements, and at the least ten horses or mules for the reserve ammunition, and we have per regiment, to be conveyed and landed, 1000 *men and* 17 *horses*. Now to the Artillery.

A 12-pounder Armstrong gun and limber occupies, with the shafts out, 14 feet by 6 feet, weighs 37 cwt. 3 qrs., and is moved by six horses, each horse occupying 8 feet by 3. The ammunition wagon occcupies nearly the same space as the gun, weighs 43 cwt. 2 qrs., and is moved by 6 horses.

The horse artillery differs only from the field battery in having 8 horses for the guns.

The forge wagon weighs 32 cwt. 14 lbs.

A battery consists of—

6 guns, 6 officers, and 243 men for Horse Artillery.

6 guns, 6 officers, and 236 men for Field Artillery.

To each battery belong 11 ammunition wagons, 11 spare wagons and carts (such as forge and medicine,) and 224 horses.

Thus we have a tolerable idea of the means required for transport either by ship or boat.

A regiment of cavalry should, I believe, consist of from 400 to 500 men and horses, with a proportion of forge wagons and carts. For each division of an army we have to land 13 horses for the staff, and for the staff of the Commander-in-chief 20 horses. The military train bears the

following proportions to a *corps d'armée* of 14,000 men, viz., 574 men and 332 horses. Ambulance wagons, medicines and medical comforts, tents, stores, reserve amunition, the corps of engineers, engineering tools, wagons, carts, gabions, &c. &c. become a subsequent operation. Possibly the supply of provisions and water may have to be kept up by the fleet, as in the Crimea, for four days after the landing. Lastly, we have the siege train, which experience tells me should be placed in vessels not impracticable, with appliances for getting out the guns.

If we multiply the foregoing by any number, we get a general idea of the requirements for conveying and landing an army, which I shall now endeavour to set before you as the fifth branch of my subject, with a view to rapid disembarcation.

It must be apparent to the most unpractised mind that the ship suitable for the conveyance of artillery and cavalry across the Atlantic, in which horses would be low down, and guns and matériel carefully and securely stowed for the voyage, would not be alike applicable for an expeditious landing. It has therefore ever been found necessary to establish a rendezvous in some commodious, safe harbour, within easy distance of the coast on which the landing was to be effected, where re-arrangements were made and final instructions issued. Such a course is absolutely essential to success. I must explain to non-nautical men, that all hoisting from the holds or lower decks in a ship, particularly of horses and guns, involves a large expenditure of time and labour, neither of which can be afforded at such a moment.

To effect a rapid disembarcation, each ship should be selected to this end and prepared accordingly. Long low ships, or ships with commodious side-passages opening from the main deck, similar to those in some of our large troop and mail steamers, are the best. The shorter the descent the soldier of infantry has to make and the more commodious or easy the way, the quicker will he reach the boat. Strong accommodation ladders, or short flights of broad wooden steps, should be attached to each side—such were fitted at Varna to every transport; rope ladders with round steps of wood, termed by seamen "Jacob's ladders," should be suspended at intervals over the side, certainly not less than two on each side, one from the fore and one from the mizen channels, to facilitate the passage of stores and seamen, who would thus not interfere with the passage of the soldiers. The horses of the regimental staff should be with their regiment, ready on the deck nearest to the boat, on which an open passageway allowed of their being lowered into the boat, the instant the weight of each animal was taken in the slings. Slings should be ready in number equal to one-third the number of horses to go, and the purchase or pulley ready beforehand.

For the Artillery:—Long, low steamers, with clear upper decks, on which should stand the guns, waggons, and horses, for a complete battery, or portion of a battery, according to the size of the ship, it being clearly understood that the horses should be in the same ship as the guns and waggons, either in complete portions, or as a whole. Large open spaces should be prepared in the sides of the ships, so that the carriages, &c. could pass out clear so soon as the weight was taken; thus there would be no hoisting, but merely hauling taut and lowering; the purchases of course

being in their places beforehand; the same description of ladder is as essential in the artillery ship as for the infantry, but on one side only, for the men. The ship adapted to artillery would be alike suitable to cavalry. In any great operation, such as the landing of an army from a fleet of transports, it would facilitate matters much, if each vessel had marked on her side, in large clear characters, the number of the regiment, or battery of artillery, she had on board. Every transport is now numbered by order of the Admiralty, when employed in that service; and it would be quite easy to add what is required. This plan was adopted in the Crimea.

Having embarked our force in suitable ships, we have now to consider the most efficient means for disembarking it rapidly, and to this end we will speak:—

1st. Of the beach party of seamen and their duties.

2nd. Of the boat for landing infantry.

3rd. Of the boat for artillery or cavalry.

The officers and men forming the beach party should be distributed in boats (independent of those carrying troops) along the entire line, and in advance of the flotilla of disembarcation; the first and second officers in command should be in the centre, *i.e.*, in advance of the centre, and the third and fourth on the flanks; their boats should in fact be the leaders of the line. Certain men should be the bearers of flags on longish poles, the heels of which should be tipped or shod with iron for the purpose of planting on the beach as marks of approach for the whole line. Should any doubt exist as to the depth of water near the beach, these boats should pioneer the way by sounding. On the signal being given to land, they should dash on for the beach, preserving their distances right and left from the centre of landing; on the *instant* of arrival at the beach, the boats, being light, should be hauled up to make way for the general line coming in; the men charged with the flags should at once plant them as marks for the line to pull to, for nothing is more difficult than to preserve the relative distance abreast without such helps.

Military officers should be associated with the Naval officers in the beach duty, though of course exercising no authority over them, the service being purely one for the sailor to carry out.

The general duties of the beach party are to aid by every means in their power the operation of landing, by hauling the full boats in, and assisting to launch the empty or cleared boats. On those points at which the artillery is to be landed, the parties should be strong, as on them will depend entirely the quick performance of this most important part of the work.

Now to the troop-boat, so called, I consider the following to be the requirements: lightness of draught; buoyancy, with commodious internal space; easy of propulsion and management when loaded; portable by shipping; security against swamping. I know of no boat yet built that combines these; the last two, viz., portability and security, in a surf being considered essentials.

An ordinary boat appropriated to the conveyance of troops should be cleared of all encumbrances, such as masts, sails, oars, and breakers, the whole internal space being devoted to the soldiers. Her equipment should

consist of *four oars*, to be pulled in the foremost extremity or bow of the boat, slung so as to prevent their separation from the boat when thrown out on touching the beach, *one* steering oar, and no rudder. At the stern part of the boat a grapnel or small anchor and its cable; at the bow, a good long rope, called technically a painter; slung on the starboard outerside in beckets a good and substantial gangboard, and from the port or opposite outerside two strong poles tipped with metal at one end; two good boathooks with beckets worked on the hooks, similar to those in the Thames wherries, for securing a rope to for towing—in fact, like those in the model on the table. The crew to consist of six men, one to steer, one to attend to anchor and cable, four to pull the oars, attend the gang-boards, &c., &c., it being, in my opinion, decidedly preferable to tow boats carrying troops, than to pull them with complete crews. Before arrangements can be made for landing it becomes necessary to test the capacity of each class of boat. I do not think any boat should have more than 40 soldiers in her at one time, if landing where opposition is certain; with that number she is not unmanageable from overweight. To use a homely phrase, "It is never wise to put too many eggs into one basket," and certainly not too many valuable soldiers into one boat, for obvious reasons.

I pass on to the boat or raft for landing artillery.

Considering the weight and space required for the gun, limber, horses, and gunners, we need a substantial safe craft of light draught, possessing the qualifications sought for in the troop-boat, and I am not aware of one suited to this work the model of which it would be wise to follow. The gun-flats extemporised by us in the Crimean expedition consisted of long, narrow, heavy Turkish stone boats, something resembling canal boats in shape (on a small scale) with greater height out of the water, each boat weighing from three to five tons, bow and stern being alike. These boats were secured in couplets, side by side, with strong transverse beams, three or four in number, as their length demanded. Over these a strong platform of planks was laid and stanchions were fixed at the angles and sides of the square thus formed. In some instances a boarding went along the sides to prevent the horses getting their legs over. When complete they must have cost about £150 each. A model of one is lying before you on the table.* Steamers' paddleboxes were coupled in a similar manner. The expense of these rough substitutes was great, the time occupied in fitting them considerable, and when completed they were clumsy, unwieldy craft, very difficult to stow on shipboard. In fact, they were necessarily fitted to be carried over in parts, to be put together at the scene of operations. Each ship carried a couple or more of such boats suspended in lashings from her side, and all the gear appertaining to them on deck. After a few rehearsals, the process of coupling them together and preparing them for work was accomplished in about half-an-hour. In the preparation of such boats or rafts it is necessary to use as few nails as possible, or that the nailheads be so countersunk as to prevent injury to the horses. I witnessed many wounds to the animals from want of attention to this item.

* Models of these flat-boats, and of the pontoon-raft proposed by Captain Mends, and presented by him, are in the Museum of the Institution.—Ed.

These boats, nevertheless, did important work, and had some points of practical utility. I am of opinion that something on a similar principle would prove serviceable: the boats being in pairs with whale-boat ends were really good sea-boats and tolerably manageable; the passage of the sea between them made it easy to keep them end on; they towed and steered easily with steering oars; each one of the larger class carried two guns with the limbers, twelve horses, and the gunners, with ease.

The French have been in the habit of using a large flat-bottomed, tray-shaped boat, called a *chalande*, of which each ship of the line usually carries two during such operations, one on each outer side, stowed flat to the side and bottom outwards, resting on strong solid chocks bolted on to the wales, as our ships of the line in the olden time carried large troop-boats. A strong parbuckle sling passes round them, with which they are hoisted into place by the yard and stay purchases, and secured by lashings; they are by these means lowered readily into the water. When stowed, the lower edges or sides of the boat are so near the water that they could not be carried in such a position in safety during stormy weather. The advantages of the *chalande* are, that they are easy of construction by unskilled workmen of ordinary wood; that they are quickly ready for work, and in fine smooth weather do a great deal for which an ordinary boat is not adapted. A model of one is upon the table. Their cost is somewhere about 100*l*. each. The disadvantages are many and serious; they are difficult to carry on shipboard in safety; they are very heavy; very slow, being difficult to tow; very difficult to steer, and very bad sea-boats. Several swamped at the landing in the Crimea, the guns going to the bottom, and the horses where instinct guided them. One, when on its passage between the ship and the shore at Varna, full of troops, was accidentally struck by a small tug steamer, which caused her instantly to founder, by which many lives were lost, the men having their packs on and arms in their hands. I hear the French have adopted a better description of boat in iron for future operations. As the Crimean war progresssd, horse-boats were built at Malta and sent to the Crimea, but they had the disadvantage of being cumbersome and weak. Similar boats have been used in the late operations in China and complained of as weak, being necessarily without thwarts and having a falling stern. Probably, some who are present this evening may know the *balso*, a small double boat of inflated hides, used by the natives on the west coast of South America to pass the surfs prevalent on their coasts, and that on these boats are brought off bread, fruit, vegetables, &c., quite dry. On the east coast of South America, we have the catamaran for the passage of equally heavy surfs, a description of craft possessing considerable stability, capable of carrying goods from one port to another under sail, easy of propulsion by paddles, and easily guided.

At Madras a similar bark passes the surf with ease, and at Galle, in Ceylon, we have the double canoe. It has struck me that the principles upon which these boats or craft are constructed—I mean the double boat of the Crimea, the balso, and the catamaran—and do well, may be advantageously applied to the construction of a raft for troops, guns, and horses. I think iron may be made available. I propose long light iron cylinders, laid side by side, connected by beams of wood and planked over to form a raft, like the model on the table, which has been made under

my directions. I think such a raft will be found to combine more nearly than any other description of craft all the requirements sought for, viz., light draught, buoyancy, commodious space, ease of propulsion and steerage, portability and safety, at no great cost—if made in our own yards about 150*l*. Every transport has in these days one or two good shipwrights, and, if she be a steamer, she has also some clever engineers; but I propose that one shipwright, assisted by seamen, shall be able to put one together. By making the cylinder boat of iron a little thicker at the bottom than at the top, we ensure to it sufficient stability or steadiness when placed in the water to receive the connecting beams and platform. The lining over the bottom is of elm, for the purpose of protecting the iron against rock or rough stones on a beach. Each cylinder of 35 feet will weigh about three-quarters of a ton, say a ton, and bear up 10 tons weight, and I see no reason why the long steam transports of the present day should not carry five of them *for war service*, three being for a gun flat and two for a troop flat. They might be secured in crutches along the outer side of the ship and lashed or stowed on skids over her quarterdeck, where some of the ships of the line carried extra boats to the Crimea. The London, I think, carried no less than eleven or thirteen good boats in that position. The wood-work should be clearly numbered so as to make it next to impossible for a man of ordinary intelligence to go wrong. I think it may be made of sufficient strength of material without adding excessively to the weight to work a field-gun upon. In case of an iron ship getting on shore, such a raft might be put together on two strong spars, laid across the gun-wales between the fore and main masts, and easily launched from that position to the sea with the aid of two up-and-down purchases.

At any rate, whatever may be its merits or demerits, I lay it before the Institution with a view to raising discussion on what is really important matter. We ought to be prepared with some well-approved model against the day of war, when any number could be run up rapidly at much smaller cost than if we had to scramble through difficulties as we did in the Black Sea, at a heavy expenditure and delay, which might have proved more disastrous in their consequences than they did.

When active war operations are going on, and the transport service is in full play, nothing requires more consideration than the stowage of war-like stores, provisions, clothing, and medical comforts in the ships selected for the purpose. Those in this country entrusted with this duty are apt to think, that, if they have got into the ship the number of tons of stores they have received orders to ship, they have done their duty. The use of cranes, and every possible mechanical appliance being brought to bear on the process of loading, the work is quickly performed, and the public is satisfied, by the announcement of the ship's departure in reasonable time, that all is well.

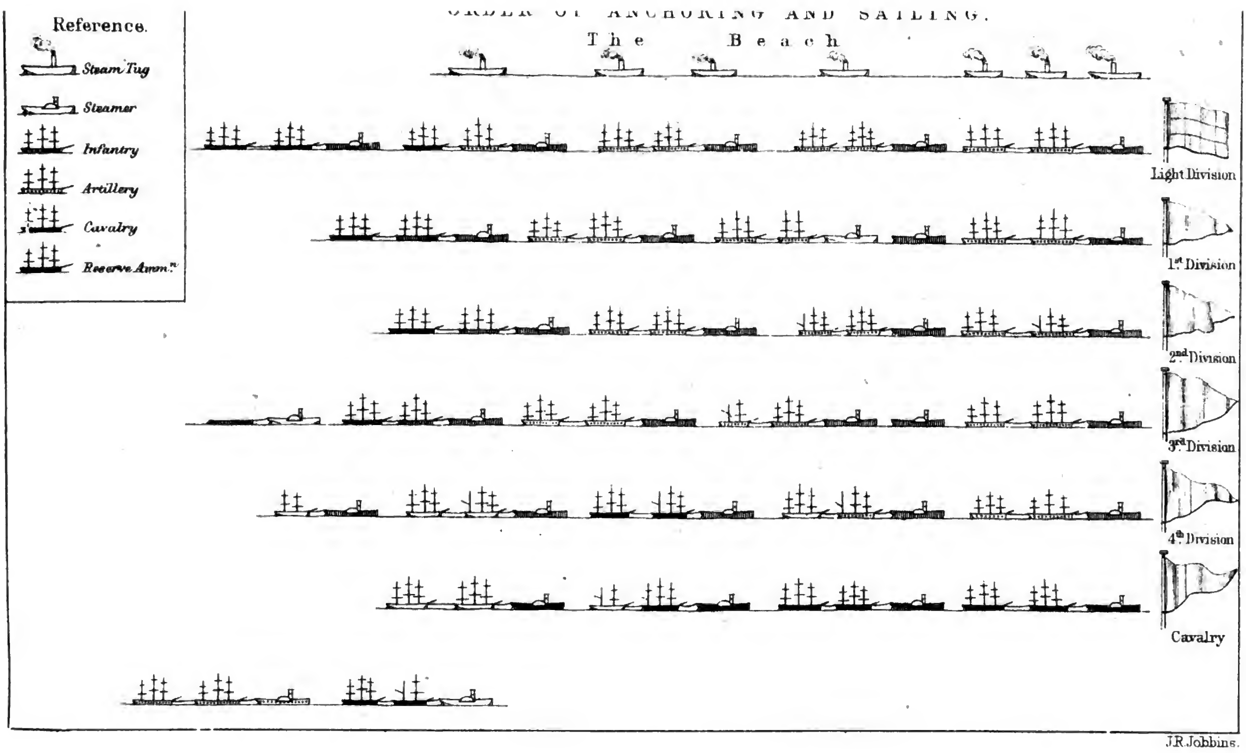
The difficulties attending the discharge at the seat of war are lost sight of, as well as the possible want of any one portion of a cargo before another. Many of the reflections on the maladministration of matters in Balaclava harbour might, with justice, have been cast upon the want of attention to this matter at home. Balaclava, a mere indent of the sea, tortuous and deep, had to contain some of the largest and finest ships the world had produced. Its inhabitants having consisted of a few petty

traders, fishermen, and government *employés*, they had not prepared fine wharves, cranes, neither a ring nor a bollard to which a rope could be secured, and yet I do not think any harbour of its size ever had had before or since so many fine vessels at one time within it. Being the first naval officer who entered, as it fell into our hands, I saw it in all its purity, a clean village resting upon a harbour, deep, clear, and unruffled, except by the ducks and geese disporting themselves on its surface, little suspecting that their career would so soon terminate in the pot of the soldier. Ships were, so to speak, tumbled in, containing provisions, tents, camp equipage, &c.; on the second morning our 91-gun ship was among the number safely moored within it, and I shall not forget the cheer with which the troops received her. The siege train was soon required; the ships having it on board were ordered in; but if two more inaccessible vessels had been looked for in the whole mercantile marine, or more inconveniently stowed, with fewer appliances for getting out such weights, I do not think they could have been found. Delay, of course, occurred in clearing them, whilst they occupied spaces much wanted for ships with provisions, &c., demands from the front pressing for everything at once.

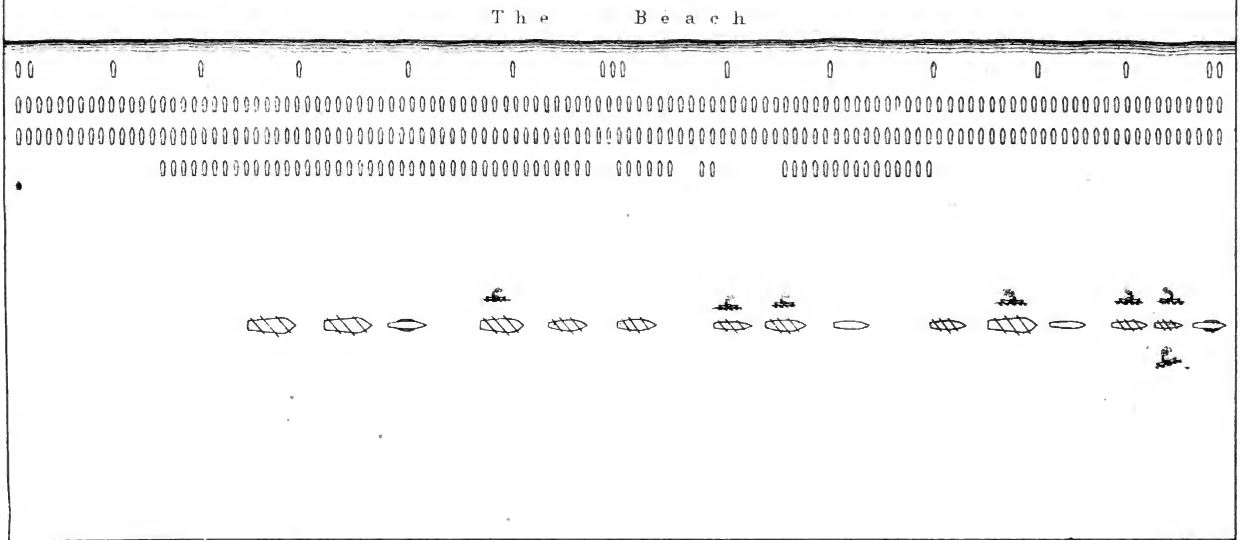
I come now to the last branch of my subject, viz., the organisation of a force with a view to rapid disembarcation. Bacon says: "For when things are once come to the execution there is no secrecy comparable to celerity." We will suppose an army embarked in ships selected, adapted, and prepared, as I have endeavoured to describe they should be, the boats and rafts wherewith to land a given number expeditiously and safely (I see nothing to prevent 10,000 infantry and 24 guns being carried at one trip; allowing each to occupy two hours, which is a long time, in six hours we have 30,000 infantry and 72 guns on shore); steamtugs (either armed or not) attached to artillery rafts; the covering gunboats told off; the pivot ships to insure a close and precise anchorage; the convoying fleet in readiness, and the highway clear; the order of sailing and anchoring well defined for night as well as day; each division carrying distinguishing flags *by* day and special lights at night, and the instructions for the operation clearly understood by all ranks. We wait the signal of the Commander-in-Chief to weigh, who doubtless would consult his barometer and tide-table before giving his order. It would insure rapidity if the ships carrying troops had the means within them for disembarking, without being dependent on extraneous aid, which from uncontrollable causes may be tardy in arrival.

Plates I. and II. represent the order of anchoring and sailing of the transports and array of boats proceeding to the shore of the Crimea with the First Division, followed by the artillery.

It remains for me to return you my best thanks for the patient hearing you have given to a somewhat rambling paper; I shall be repaid if it induce professional men to turn their attention to the very important subject of disembarking troops; for, though England is not an aggressive nation, circumstances may compel her again to land troops on a foreign land, unless indeed (*unhappily*) the brick and mortar defences rising around us should lull the nation into a false security, and induce England to yield up her natural strength for attack or defence upon the sea.


ORDER OF ANCHORING AND SAILING.
The Beach
Reference.
Steam Tug
Steamer
Infantry
Artillery
Cavalry
Reserve Amm.n
Light Division
1st Division
2nd Division
3rd Division
4th Division
Cavalry
J.R.Jobbins.

ORDER OF LANDING.



J.R. Jobbins

Lord De Ros: Could not the pontoons that are used for military bridges be made available? They are of the same shape.

Captain Mends: I think they might; but I rather think the pontoons are made of equal thickness of iron, and you want a certain stability. If you have the least sea on in putting them together, they would wobble about immensely. That is the difficulty. I think by giving them a thicker iron at the bottom than at the top you give them a certain stability; and then the seamen would have less difficulty in putting them together. They are easily launched, and I think one ought to be put together in twenty minutes if the men are well practised.

Lord De Ros: I apprehend that with the same materials for landing infantry you could make two pontoons.

Captain Mends: Yes; I think so: they might make two for infantry, but one for guns and horses.

The Chairman: I would only observe here that we are greatly indebted to an officer whose official duties occupy a great deal of his time, for preparing so elaborate and so complete a statement as he has given us this evening. The question is one of the highest importance; and the more it is considered the more apparent are the difficulties we have to contend with in carrying out an operation of this kind. Completely as Captain Mends has gone into the question of landing, there is yet a further point, respecting which I hope some gentleman present will give us information, and that is, as to the erection of piers for embarcation, in an artificial manner. Where there are a great many troops engaged, the erection of piers is of the greatest importance. I should also like to know—I do not know whether recourse was had to it in the Crimea—whether oil, or something of that kind, could be used to prevent the effect of swell upon the beach.

Lord De Ros: I dare say Captain Mends will recollect, at Varna, the French piers were made of casks, which answered admirably well for the embarkation; and that our own engineers on the opposite side of the bay used faggot-piers, made very ingeniously. They answered exceedingly well. They were merely made of faggots pegged in; they became very solid when the earth was put on, and lasted a long time.

Commander Scott, R.N.: Where would the covering vessels be placed with respect to the fleet of transports—the vessels to protect the landing if the landing were opposed?

Captain Mends: The covering vessels would anchor in a position with respect to the beach where the draught of water would enable them to cover the whole line, on points settled by the Naval Commander-in-Chief at the time. The covering vessels are not shown on the diagram.

Commander Scott: I asked the question because it is an important part of the arrangements—the position of the covering vessels—if a landing were opposed.

Captain Mends: There is no doubt of it.

Commander Scott: You mentioned, particularly, the decks of your transports. Do you intend the transports to carry guns or not?

Captain Mends: I think not.—The Chairman made some reference to artificial piers. It was seriously contemplated—in fact, had the surf held on another four hours, we should have sunk a couple of transports to protect the beach. They would have formed a very good breakwater in a very short time. No one would have hesitated to do such a thing. In fact, as the men had been landed with only three days' provisions, I should have done it on the setting in of bad weather, had I been in command.

Lt.-Colonel Collinson, R.E.: I should like to ask whether Captain Mends has ever considered the arriving at any organization of a system of disembarking troops; so that, not each vessel, but each division of vessels, should be able to proceed by signals without waiting for further arrangements? I think you propose that each transport should carry the means of disembarking troops. I should like to ask whether you have determined upon any particular size or description of raft, to carry a certain number of troops, so that vessels could be supplied with the required number? So that there would be, as it were, a certain unit of disembarcation—rafts of a particular size to land a certain number of troops, vessels of a fixed tonnage capable of carrying a definite number of troops, supplied with the requisite number of rafts for that purpose. I also wish to ask with respect to that model of a raft, what is the scale of it, and the number of men it would carry? I daresay you are quite aware of the description of pontoons used in the British service. I should think they are rather larger than those which you have shown, though somewhat of the same appearance and shape.

Lord De Ros: The pontoons are thirty feet long, are they not?

Lt.-Colonel Collinson: No; they are twenty-four feet; and they are placed, gene-

rally, at an interval of twelve feet, and they are so organised and manœuvred that they are capable of being worked in pairs to form a raft about twelve feet by ten, possessing a buoyancy sufficient to carry thirty men. That raft can be worked in the tidal way of a river, but I do not know that it has ever been tried in a sea-way at all.

Lord De Ros: You are alluding to General Pasley's raft, a boat-shaped raft.

Lt.-Colonel Collinson: No; not General Pasley's, but General Blanchard's cylinder raft; that is the one which is now used in the British service. General Pasley's is not the same shape, but made of the same material, which is metal. There has also been another description of pontoon lately proposed which has been brought before this Institution, the invention of Captain Fowke, of the Engineers.* It is a portable raft made of canvas. It may be briefly described as being transverse frames of wood, connected together by canvas, so that they collapse longitudinally into a space of three or four feet cube, and will expand into a long boat-shaped cylinder; not a closed cylinder at all, but a boat-shaped cylinder with an opening—a sort of long hatchway in the top of about twenty-two feet long, and four or five feet beam. Two of these together would give a very considerable buoyancy. There is, of course, a difficulty in using canvas vessels in water, and that is to keep them rigid underneath at the bottom, which causes a very great obstruction to the movement in the water, requiring a very great power of movement to propel them. I suspect that in using any description of pontoon raft, whether of canvas or of metal, there will always be found very great difficulty in moving them in the water. They would require considerable power. Otherwise, if you have that power, which perhaps you may obtain by steam, then they offer very great advantages from their stability and buoyancy, and their flat deck. Therefore, what I want to ask, with respect to that particular raft, is, the power or buoyancy of it, the space in it, whether it is available for infantry, cavalry, and artillery; and whether you have in your mind a sort of unit of a raft that would be available for all services, and as to how many of them a vessel, of any tonnage you like to mention, would be required to carry: and further, if you could state, with any degree of determination, the time that would be required to land any definite number of men; because of course that must depend upon the unit that you adopt.

Lord De Ros: And upon the weather.

Lt.-Colonel Collinson: We must assume a certain definite weather. If we go into that question we shall have an endless discussion.

Lord De Ros: The canvas would hardly do on a beach.

Lt.-Colonel Collinson: I will assume favourable weather, a favourable beach, a favourable opportunity, and you have got to land a division of the army, or any section of the army that you choose to name. How many boats or rafts would be required to land them in a certain time? Is it possible to state that, so that, by simply multiplying the number of rafts and vessels, you would be able to land any force you please in a given time?

Captain Mends: In drawing up this paper I had in my mind specially, rapid disembarcation. I cannot say I have gone closely into the calculation so as to answer correctly the questions you have put to me. Nor would it be possible to do so, unless the whole of the transports employed were alike in the first place. It must be a thing to be organised at the moment. Some practical person conversant with the whole affair must organise it and arrange it at the moment. I certainly feel that, in order to disembark rapidly, the transports should have within them the means of landing the men; that they should convey their boats, and rafts for artillery, if requisite; that the steam-tugs should be near them, and that they should do the whole work, having men in them to hoist the guns, horses, and gear out, independently of the troops, and independently of the ships of war. I feel satisfied it would be more quickly done. I see no reason whatever, assuming a fleet of transports near the shore with proper organisation, why ten thousand men, with twenty-four guns with their limbers and horses, should not be landed in two hours. Therefore, in six hours, I would have thirty thousand men and seventy-two pieces of artillery on shore. I think it ought to be done, and I think it can be done. I have not seen Captain Fowke's pontoons; I have seen the cylinders of light iron used by the engineers for pontoons, but I have never seen anything approaching to what I conceive would be useful in even moderate weather at sea. The length of each of these cylinders on the table would be thirty-five feet in the extreme, and it would have a displacement of ten tons, sixteen hundred-weight; so that, with four, I could get to bear about forty-three tons. The platform formed within the square is thirty feet square, so that I could certainly carry

* For a description of this raft, see Journal of the Institution, vol. iv. p. 237.—Ed.

with perfect ease two guns, limbers and horses for them, and I should think about seventy or eighty men would stand upon that platform. I have not tried it, but I guarded myself in my paper in that particular, that it is always necessary, previous to embarking, to rehearse and test what each boat will carry before you draw up the arrangement. In the landing at the Crimea we were obliged to go through the experiment with every class of boat, and we knew exactly what each could do. I arranged for landing six thousand four hundred men and twelve guns in each trip. Had all things gone on in accordance with the arrangements, I believe I should have landed them in six hours; I see nothing to have prevented it. Of course such an operation depends upon the precision with which the fleet of transports is brought to the anchorage before the beach,—the sea, and so on.

Lord De Ros: Captain Fowke's pontoon is capable for river, but it would not do for beach work.

Captain Mends: It has been suggested to me since this model was made, that it would not be perforated by musketry, and, even if struck by a shot or two, the raft would not give way at all. I do not see how Captain Fowke's pontoon could be used upon a beach.

Lord De Ros: The canvas would tear to pieces.

Captain Mends: It was suggested to me to run a fore-and-aft compartment, a longitudinal compartment, in each cylinder; it would strengthen them very much without adding much to their weight. They would not then weigh a ton each, and would certainly stand a shot or two.

Lt.-Colonel Collinson: How would you carry them on board ship?

Captain Mends: I stated in my paper that they could be slung outside, lashed in crutches, where I think they could be carried in almost any weather, or on skids over the quarter-deck.

Lord De Ros: Do you hold much to the thickness of the bottom? because they are very easily steadied, and immediately they are placed in the water the oars can be used.

Captain Mends: When you first put them over into the water, with the least ripple at all, they would roll about, unless steadied at the bottom. It would be a great thing that they should be in some measure floated upright before being connected, in order to facilitate the operation.

Lord De Ros: They would not turn in the slings till you got the sleepers across on them.

Captain Mends: But they must be thrown over altogether. They must be run into the water, and the seamen should be able to lash the spars to them across the top, and they must be steadied while the seamen connect them, with the three spars underneath. I think that would be quickly done with a common lashing; the first lashing or two will steady them. With a little rehearsal and a little exercise I would undertake to rig a raft of this sort, with some good seamen and a shipwright, in twenty minutes.

Lt.-Colonel Collinson: Supposing you had to carry a battalion of eight hundred men in one vessel, I think that raft, by your description, ought to carry one hundred and twenty men.

Captain Mends: I daresay it would, but I should be very sorry to put one hundred and twenty men upon it to land on a beach if there is the least chance of opposition. I must however say this was entirely departed from in the Crimea; we had little light draught steamers purchased from an Austrian company, and each of them carried a regiment. I think the Guards were then very near a thousand strong, they had not then been decimated; each one carried a regiment of Guards, and ran in on to the beach, and the disembarcation was done most rapidly.

Lt.-Colonel Collinson: Supposing the raft carried one hundred men, then, a transport that would carry a battalion would require eight such rafts; that is, thirty-two of these cylinders or pontoons.

Lord De Ros: That is to suppose you would land all at one trip, which you would not do.

Lt.-Colonel Collinson: I suppose, when you say you would land ten thousand men at one trip, you mean that you would take that number of men out of a certain number of vessels?

Captain Mends: No, because you could not get the men rapidly enough into the boat; you could take a certain number of men, but you would not be able to get a sufficient number of boats alongside at once for so large a number from one ship.

The Chairman: I am sure you will join with me in returning our thanks to Captain Mends for his kindness in reading this able paper.

Evening Meeting.

Monday, May 5th, 1862.

CAPTAIN E. G. FISHBOURNE, R.N., C.B., in the Chair.

Names of Members who joined the Institution between the 7th April and 5th May.

Life.

Evans, T. W., Dept. Lieut. Derbyshire, 9*l.*
Vernon, Lord, Major, Derbyshire Rifle Vols., 9*l.*

Annual.

Adams, C., Lt. Col. 49th Regiment, 1*l.*
Arthur, W., Comr. R. N. 1*l.*
Allardice, G. J. C., Ens. 50th Regt. 1*l.*
Baynes, G. E., Major, 1st Bat. 8th King's, 1*l.*
Benyon, W. H., Ens. 2nd Bat. 23rd R. W. Fus.
Cockran, T., Capt. R. N. 1*l.*
Crofton, H. A., Captain, Adj. Monaghan Mil. 1*l.*
Currie, A. D., Ens. 41st Regt. 1*l.*
Doveton, J. E. C., Ens. 50th Regt. 1*l.*
Dunn, J., Ens. 41st Regt. 1*l.*
Gage, Hon. E. T., Lt. Col. R. A. 1*l.*
Garratt, F., Capt. late 3rd Dn. Gds. 1*l.*
Hardy, F., Capt. 84th Regt. 1*l.*
Johnson, E., Lieut. Rifle Brigade, 1*l.*
Maunsell, F. R., Major Roy. Bengal Eng. 1*l.*
Moore, R. C., Col. Royal Madras Art. 1*l.*
Nepean, E. C., Esq., Clerk at War Office.
Pinder, G., Col. Retd. Full Pay, 1*l.*
Scrymgour, W., Capt. R. N. 1*l.*
Skipton, S. S., Asst. Sur. 78th Highrs. 1*l.*
Smith, F. H., Com. R. N. 1*l.*
Smith, J. W., Ens. 2nd Bat. 1st Royals, 1*l.*
Symonds, C. E. H., Lieut. R. A.
Tupper, D. W., Capt. 50th Regt. 1*l.*
Turner, G. Esq., Master Shipwright, 1*l.*
Williamson, R. F., Ens. 2nd Bat. 23d R. W. Fus.

THE SHAPE OF SWORD BLADES.

By Mr. JOHN LATHAM, firm of Messrs. Wilkinson and Son.

In the course of an experience of nearly twenty years in the manufacture of swords, I have frequently noticed in examining any pattern, or model, which I have not met with before, how instinctively the shape seems to suggest the best method of using the weapon; and I have almost invariably found upon inquiry that the method of swordsmanship adopted was the same that I had supposed.

A moment's reflection is sufficient to show that there is nothing extraordinary in this. A swordsman selects or constructs his weapon on exactly the same principles as a carpenter chooses his tools, and if you show a workman a chisel from any part of the world, though he may

never have seen the pattern before, he will tell you at once the use to which it should be applied. He will know, for instance, that it is not intended to drive nails, or bore holes; that its office is to cut wood or some soft substance, and not iron or steel. He recognises these points at once from the shape, the angle of edge, its temper, weight, &c.; and in the same way, by examining a sword of whatever country, we can form a pretty correct estimate of the method of swordsmanship adopted there. Having noted a great number of peculiarities of this kind, some of which seem to me very curious, I have arranged them in a short paper, in the hope that they may prove as interesting to you as they have been to myself.

We may very fairly surmise that the origin of the sword as a weapon of attack was the idea of some ingenious savage, who fashioned his wooden club to a rude approach to a cutting edge, probably from noticing the effect of a knot, or some accidental projection upon it. The wooden swords with which the Mexicans were armed when first discovered by the Spaniards, and those of the South Sea Islanders, of which there are many specimens in the Museum of this Institution, are instances of this, being hardly more than sharpened clubs.

In nations more civilised, swords were made in the hardest metal procurable. Copper swords have been found in Ireland; iron among the Britons and Gauls; bronze was used by the Romans, and probably by the Egyptians; and steel of varying degrees of hardness is now the only metal employed.

Upon the questions of the material, temper, or manufacture of swords, I do not propose to touch, but only upon their shape, which is, as I have said, determined by the way in which they are to be used. There are three ways in which a sword may be used, viz. in cutting, thrusting, and guarding. The first of these, cutting, I have assumed to be the earliest use which would suggest itself; but the man who first employed the sword for thrusting made a discovery which more than doubled the effective force of the weapon; and, still later, the one who first used it to defend himself from the attack of his adversary, as well as to return his blows, completed the idea of the sword, as it is now understood in Europe. It is in this triple character, as a weapon for cutting, thrusting, and guarding, that I propose to consider it. If these three qualifications could be combined in their fullest extent, there would be no difficulty in deciding upon the best form for a sword; but, unfortunately, each interferes with the other to a great degree, and therefore it will be best to consider them separately, which will also enable us to understand more clearly the various modifications of shape in use in different parts of the world.

The most simple and effective form of a cutting instrument, to be used by the hand, is the American axe. This is the same form as the early headsman's, or executioner's, axe, but is generally known in this country as the American, from its being the form used by the settlers for clearing the forests in the backwoods of America. It consists merely, as you see, of a heavy wedge of steel, fixed on a stout wooden handle of convenient length.

The first thing we notice in this weapon is, that there is no uncertainty where you shall strike with it. It has a light handle and a very heavy

head, and, all the force being concentrated in the head, you strike instinctively with that part of it; but, if you take up a sword, you have the whole length of the blade to choose where you shall cut with it. Suppose you make a cut at a branch of a tree with the point of the sword, the probability is that your cut will produce very little effect, and you will feel a considerable jar upon the wrist and elbow. The same result will follow if you cut close to the hilt of the sword. In either case you waste a great deal of force, as is evident from the vibration you perceive in the blade, which represents so much force lost in the cut. If you go on cutting inch by inch along the whole length of the blade, you will at last come to a point where there is no vibration (Plate I. fig. 1, C. P.). This point is called the "centre of percussion," and that is the point where the whole force of your blow will be effective, and where the greatest result will be produced on the body struck. This model on the table illustrates the position and effect of the centre of percussion. It consists of a straight wooden blade jointed in the middle so as to bend freely in either direction, and the centre of percussion is marked, as you will see, at about 10 inches from the point. If I set the blade straight and cut with it, so long as the blow strikes exactly upon the centre of percussion no effect is produced upon the blade; but, if I shift the cut either an inch above or below that point, the vibration produced causes the blade to bend at the jointed part; if I strike above the centre of percussion, the blade bends backward; and, if I strike below it, the vibration is in the opposite direction, and is sufficient to bend it forwards considerably. As I have explained, the centre of percussion can be experimentally ascertained by cutting inch by inch along the blade, and comparing the effect; but it is obviously of importance to have some means of ascertaining this point mathematically without the tedious process of experiment with every sword. This can be done by a formula, first proposed by Mr. Henry Wilkinson, and which is based upon the consideration of the properties of the pendulum. I have here a pendulum vibrating seconds in the latitude of London. Its exact length is 39·2 inches, and it consists of a very light wooden rod, terminated by a heavy leaden ball. In one respect it resembles the axe, as nearly the whole weight is concentrated in this one point. When I cause it to swing upon a fixed centre, I find it makes sixty vibrations in one minute; and I know that the centres of oscillation, of percussion, and of gravity are all concentrated within this leaden ball. If this were what is termed a mathematical pendulum, in which the connecting rod is supposed to have no weight at all, these three points would lie precisely in the centre of the ball, and from this point to the point of suspension is exactly 39·2 inches. Now, I hang up this regulation Infantry sword, fastening it as nearly as possible at the same point on which it would turn in making a cut, and I set it swinging upon this point, converting, in fact, the sword into a pendulum. You observe that the vibrations are very much quicker; if you count them, you will find that while the pendulum is making sixty vibrations the sword will have made eighty. Having obtained this point of comparison, our object is next to determine the length of a pendulum which will make the same number of vibrations which the sword has made, viz. eighty in a minute. By a very simple formula, I can calculate that the length of such a pendulum would be 22 inches. I measure this distance, therefore, from the point at which the sword was

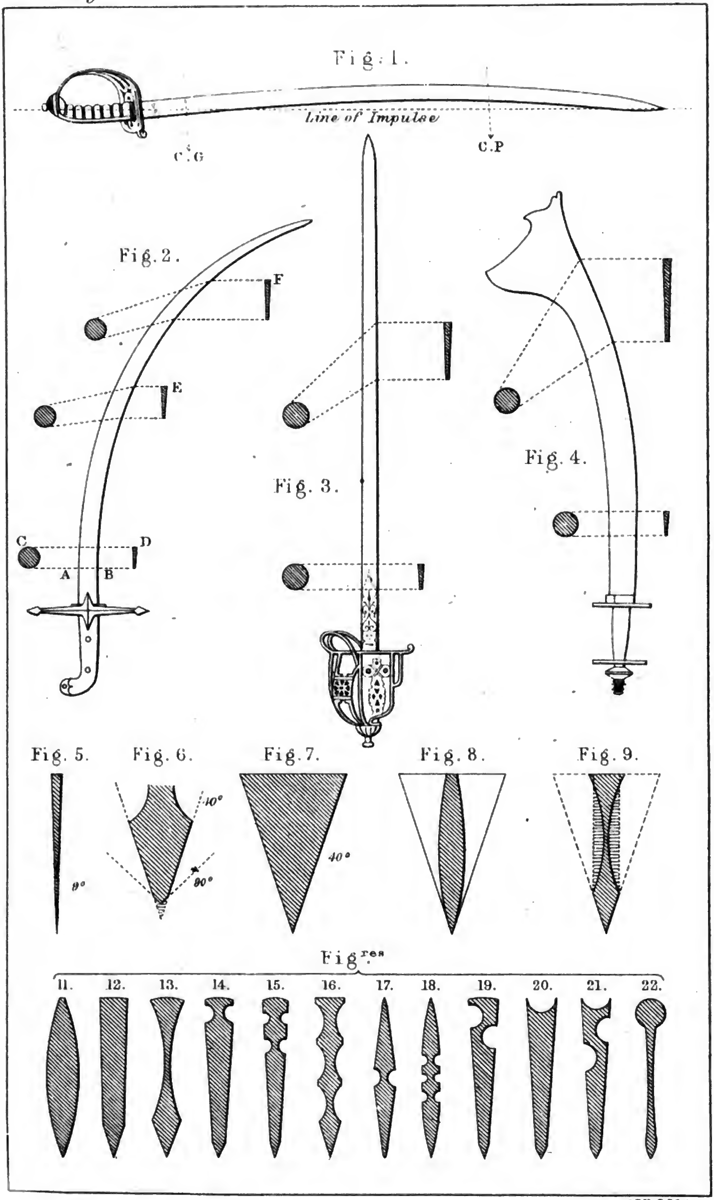


Fig. 1.
Line of Impulse
C.G
C.P
Fig. 2.
F
E
C
D
A
B
Fig. 3.
Fig. 4.
Fig. 5.
9°
Fig. 6.
40°
90°
Fig. 7.
40°
Fig. 8.
Fig. 9.
Figres.
11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22.

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suspended and mark it on the back of the blade, and I shall find on cutting with it that this mark is the centre of percussion, where there is no vibration, and where I can cut the hardest with this sword.

Another point which we notice in examining the axe is this, that the cutting edge is considerably in advance of the wrist or hand. The effect of this is to carry the edge forward in the direction you wish it to take in making a cut with it. If the cutting edge were placed at the back, the tendency of the whole weapon would be to fall backwards, or away from the line of your cut; and in making a blow you would have to exert and waste a certain amount of force to overcome this tendency. Instead of this, the edge of the axe, being placed in advance of the wrist, moves naturally in the direction of the blow struck with it.

In nearly all cutting swords some contrivance is made use of to produce a similar effect. If we examine any of these curved swords we shall see that the line of the hilt is thrown forward so as to form an angle with the line of prolongation of the blade, and this angle is more or less as the blade is more or less curved. If you endeavour to balance the sword upon the pommel or rivet, you will see that the effect of this is to cause the edge to fall forward precisely as the axe does. This gives the feeling which we express when we say of a sword "the edge leads forward well;" and I have nearly always found this point has been studied in the swords used by nations who make cutting a part of their system of swordsmanship.

But the curved blade which is so universal among these swords has another and very important effect, which you will understand from this diagram.

In making a cut with a curved blade, the edge meets the object at a considerable angle, and the portion of the blade which penetrates is therefore a wedge, not accurately at right angles with the sword, but of an angle more or less oblique according to the curvature, and consequently cutting with a more acute edge. In this diagram (fig. 2), if the sword-blade move in a straight line, A B, to cut any object, C, it will merely cut in the same way that a wedge, D, of the same breadth as the blade would do. But the effect of the curve is to throw the edge more forward, so that it cuts as a wedge, E, which you will see is longer and consequently more acute, the extreme thickness (that of the back) being fixed. In the same way in cutting nearer the point the increased curve gives, as you see, the effect of a still more acute wedge, F. In order to explain this more clearly I have made a small model similar to the diagram. If you compare these three pieces, which are parts cut out of the same blade, differing only in the angle at which they are supposed to meet with any obstacle, you will see the enormous cutting power which is produced by this oblique motion of the sword. We may say that the effect of the curve in this Indian tulwar, as compared with a straight blade, is, that it cuts as though it were four times as broad and only one-fourth the thickness. I have selected the tulwar as an illustration, because we have all heard of the extraordinary effects produced by the natives of India in cutting with this weapon. Men inferior in stature and bodily strength to our own countrymen can use this weapon so as to produce effects which strike us with astonishment:—heads taken off—both hands severed at the wrist—arm and shoulder cut through—legs taken off at one blow. Such are the sword-cuts of

which our soldiers had too fearful experience during the Sikh war and later campaigns in India.

To understand more clearly how such effects can be produced, we must distinguish the different methods of cutting. In the first place I may take up a sword, and, keeping the elbow and wrist stiff, may make a sweeping cut with it, throwing the whole force of the body into the blow. To use as simple terms as possible, I will distinguish this as the "slicing" cut. In the next place I may take the sword, and, as an Englishman generally does, make a downright blow from the shoulder and fore-arm. This appears to be the instinctive method of cutting with a sword, as we find that most people who take up a sword for the first time use it in this way. We may distinguish this as the "chopping" cut. Or we may use a light sword in the way the German students use the "schläger" in their duels, keeping the elbow and arm stiff and making a quick cut from the wrist. This we will call the "whip" cut.

Now very different muscles are brought into play in these three methods of cutting. With the Indian tulwar, the first, or slicing cut, is used, and in this the cut is really given from the strong muscles of the back and shoulder, and, as these have nearly ten times the extent of the muscles of the arm, and the whole weight of the body is also thrown into the cut, you can easily understand the force with which such a blow is given. The second kind of cut, which is the one usually employed in Europe, is made with a movement of the shoulder and forearm. As a rule it cannot be compared in its effect, especially upon soft bodies, with the slicing cut given by the natives of India, and the large hilt, necessary to afford sufficient play to the wrist, lessens the cutting force still further. The small hilt of the tulwar, by confining the hand and preventing any play of the wrist, increases the force of the slicing or body cut. It is customary to say that these swords have such small hilts because the natives have small hands. My own hand is not a very small one, but I find no difficulty in using any of these Indian swords in the way in which they are intended to be used. The hand being confined in the hilt gives a stiffness to the wrist, so that the whole force is thrown into the blow. The wrist-cut can also be used with great effect, from the high velocity which can be given to a light sword by using it in this way. The German students who use this cut in their duels with the schläger are frequently fearfully cut about the face, and even the quilted leather pads with which they protect the body are sometimes cut through. It takes very little weight to cut flesh, or any soft substance, if sufficient velocity be given. The cut from the shoulder and fore-arm is most effective upon any hard substance, such as iron, wood, or lead.

To estimate the effect of a sword-cut we will take the formula generally in use for expressing the *vis viva* or force of a moving body, which is, the weight multiplied by the square of the velocity. Assuming this formula (which, however, requires considerable qualification), we will suppose a strong man, cutting with a sword of 4 lbs. in weight, to which he is able to give a velocity which we will call 1. The effect produced we will therefore call 4. We next suppose a weaker man who takes a sword 2 lbs. in weight and able to give it a velocity double that of the first, the effect produced will be equal to 8, or *twice* that which can be exerted by the stronger man using the heavier sword. But let us suppose that the

strong man takes the lighter sword; he will be able to give it a higher velocity, which we will assume to be equal to 3, in which case the effect produced, squaring the velocity, will be 18, or *three* times the effect that is produced by the same sword in the hands of the weaker man, and more than *four* times the effect which he himself could produce with the heavier sword. I merely take this illustration as showing that the force of a blow is enormously increased by increased velocity, but much less by increased weight in the moving body. The nature of the body cut at, however, affects the result very much, but the common error is, that a very strong and powerful man chooses a heavy sword and fancies that he can do more with it than he can with a light one. Because he feels that it requires a greater exertion of strength on his part to put it into motion, he naturally fancies the effect produced will be greater; whereas by taking a lighter sword, to which he can give a higher velocity, he will do better. Of course I do not mean to say that the lighter the sword a man uses the greater the effect he will produce with it, but merely that there is a limit as to weight, which is generally exceeded.

The weight a man can move with the greatest velocity is that with which he will produce the greatest effect, but the lightest sword is not necessarily the one he can move the quickest. It is possible for a sword to be so light that we feel the resistance of the air in making a cut with it, and this is what we express when we say a sword feels "whippy" in the hand. Such a sword is worse than one too heavy.

Another point in a sword is the position of the centre of gravity (fig. 1, C G.) This is not what we generally mean when we speak of the "balance" of a sword, which term is applied to a feeling of the weapon in the hand which results from the relative positions of the centre of gravity and the centre of percussion. The considerations as to the position of these two points would take too long for me to explain to you now. It may be sufficient to say that in light swords these points may be further apart than in heavier ones, that they should be closer in a straight than in a curved blade, and nearer in a thrusting than in a cutting weapon.

We will next examine the sections of weapons used for cutting. These are of course all modifications of the wedge. I have here an illustration consisting of a series of wedges, representing sections of different sword-blades. The first form (fig. 5) is the wedge which would be produced by taking the thickness of the back of an ordinary sword and continuing it in an even line down to the edge. This forms an angle of 9°, which is very much too thin for any practical purpose. We find that a certain thickness is necessary for the edge of any cutting tool. For a very soft substance, as flesh or food, it may be from 10° to 20°, and this is the angle we find in dinner knives, &c. For wood an angle of 25° to 35° is the best, and this is the angle of a carpenter's chisel or plane. For cutting metals or bone the angle required is from 40° to 90°; and, as a sword-blade may meet with substances as hard as these, the least angle which we can give it with safety is 40°. Even this angle will fail against a hard substance if the cut is not a very true one, and we therefore put on a still more obtuse angle, viz., 90° at the extreme edge, as shown in fig. 6, where these two angles are distinguished as the entering angle 90°, and the angle of resistance 40°. You will also see by the outline (figs. 7, 8, 9,) that a

true wedge of 40° would be of such enormous thickness and weight as to be useless for a sword, and we have to find some method of lightening the blade, while preserving the necessary angle of resistance. The following sections of blades show the principal methods of effecting this object. In figs. 9 and 12 the two sides are cut away to a flat surface—this is the general form of the Mahratta or Hindustan tulwar. In figs. 8 and 11, the angle is carried in a curved line to the back, which is made very thin, giving the section a bi-convex form. This is the shape of the celebrated Khorassan, Persian, and Damascus blades generally. Both of these plans give a very strong but heavy blade. The third form Nos. 9 and 13, in which the blade is hollowed into two broad grooves from the angle of resistance, making the section bi-concave, is that adopted in the English regulation sword blade. These drawings being made to scale, you can readily estimate the relative amount of metal in each of them, and you will see that this form gives the lightest blade for a given breadth and thickness. I believe it was this consideration which determined its adoption in the service; but it is not by any means the strongest form, and there are other technical objections to it which I will not enter into.

Nearly all the other forms of blade are also grooved, as you will see, though in a different manner, and I should here explain a peculiar function of the groove which renders it of great use to us. One of the most important requisites in a sword-blade for real service is *stiffness*. There is no possible use of a sword in cutting, thrusting, or guarding, in which too great flexibility would not be a disadvantage. It is a singular illustration of the little attention paid to this subject in England, that this very *defect*, flexibility, is frequently assumed as the criterion or test of a good blade. The blade which springs the most easily, is called the best; whereas nothing is easier, by making the blade thin enough, and useless enough, than to produce a sword which shall bend twice round the hilt and go into a hat-box, or clasp hilt to point and form a waist-belt—both of which wonderful swords I have myself made. The error arises from confounding flexibility of the blade with elasticity of the steel—the latter is necessary, the former useless and always injurious. But to resume: a blade which has been ground thin to lighten it, will frequently be too flexible and whippy. In this case by putting a groove on each side (see figs. 13, 14, 17,) we not only make it still lighter, but we also make it *stiffer;* for if we apply any force to bend a grooved blade sidewise we meet with the greatest amount of resistance which any mechanical form can supply. We are, in fact, bending an arch inwards upon its crown, and of course the deeper the arch the greater the resistance, which explains why the narrow groove in figs. 14 and 17 is preferable to the broader groove of the same depth in fig. 13.

The blade fig. 14, with a narrow groove on each side near the back, is a very old form and a very good one; the weak point of it, that is, the part between the two grooves where the metal is thinnest, is in the best place, viz., near the back, where strength and thickness are of the least importance; in this respect it is superior to the regulation form No. 13. The next blade, No. 15, is rather lighter, but is open to the objection that it has two of these weak places instead of one. The blade No. 16 is better in this respect, it has three grooves, which are much shallower, and the blade is consequently thicker between them. The same remarks

will apply to Nos. 17 and 18, which are sections of the single-grooved and three-grooved claymore blades.

An ingenious method of obviating the weakness caused by deep grooves in a blade is shown in fig. 19, which is the section of a very curious blade made at Klingenthal, the sword manufactory established by the first Napoleon on the banks of the Rhine. In this two very deep grooves are cut in the blade, but not opposite to each other, so that the groove can be made even deeper than the line of axis of the blade. This gives very great stiffness; but I found, on testing it, that it was deficient in cutting power. I may have been erroneous in my judgment, for I was not able to make any very careful comparative trial, but such was my impression, and I could only attribute it to the depth of the groove passing beyond the axis, which might cause loss of power by vibration. Nos. 20 and 21 are experimental blades; the groove in No. 20 is placed at the back so as to preserve the sides of the wedge intact: there was great difficulty in grinding this sword, and the groove being in the back it hardly stiffened the blade at all. The resistance of the crown of the arch was wanting, and the blade sprung almost as readily as a straight sword. No. 21 is another combination which I tried, but, although having some good points, it was on the whole a failure. No. 22 is the old ramrod-back regulation blade, and I believe it to be the worst form of any; the very sudden change from the thick round back to the thin edge, renders it hardly possible to get a blade of equal temper, and the back acts as a check or stop in cutting with it.

There is another curious form of cutting-blade in which the curve is the reverse way to the usual form. Instances of this form are seen in the Khora, and Kookree knife of the Ghoorkas. In tools we have a familiar illustration in the billhook used to lop off small branches of trees, and in some forms of pruning-knives. The Kookree knife is the best known weapon of this kind, and the stories related of its cutting power are very marvellous. If you examine it you will find that the weight is well forward, and in advance of the wrist, and in fig. 4 you will see that the effect of the inward curve is to increase the cutting power by rendering the angle more acute. It acts, in fact, in precisely the same way, but in an inverse direction, to the outward curve in the blade, fig. 2.

Straight cutting swords, of which we have many examples—for instance, the claymore and the old fox-blades of Cromwell's time—are all of them necessarily inferior to curved blades in their power of cutting. They may be made to cut better by the simple expedient of making a drawing or slicing cut with them; this produces in some degree the oblique action of the wedge, which is produced naturally by the curve of the cimeter blade (see fig. 3).

There is another method of using the curved blade, which is in fact a combination of the cut and thrust, by thrusting the edge forwards and along the body aimed at obliquely from point to hilt. It is hardly possible to apply much force in this way on foot, but on horseback, where the horse is moving forwards and supplies the necessary force, it is very effective and difficult to guard.

There is another very curious sword, the Dyak sword, from Borneo; the tassels ornamenting the hilt, which are said to be tufts of human hair, corresponding in number with the heads which have been taken off

by the blade. This sword is broadest at the centre of percussion; the edge leads well forward in advance of the wrist, ard, combined with the inward curve (though this is very slight), gives great cutting power to the weapon. In this Mahratta straight sword you will notice how very marked is the throwing forward of the edge of which I have spoken; it bends away in advance of the hilt to an extent of two or three inches. The old light cavalry sword of George III. is an excellent weapon for cutting; light, thin, and very much curved, and with the hilt thrown well forward. In fact this position of the hilt, of which I have endeavoured to explain the reason, may be traced to a greater or less extent in every cutting-sword with which I am acquainted, with only one exception. This single exception is the Japanese sword-blade, in which, as you will see by this specimen, the line of the hilt corresponds with and is a continuation of the curve of the blade. I have not been able to learn any particulars of the way in which these swords are used, but I cannot conceive any method of cutting in which this position of the hilt would be advantageous. Here is another curious illustration of the analogies between the weapons of very remote nations. This wooden club or sword is selected from one of the South Sea Island trophies in the Museum of the Institution, and if I place it side by side with this elaborate steel weapon, the Khora of Northern India (fig. 4), you will see how perfect is the resemblance in shape. The coincidence in every point is too close to be accidental; it is evident that the same principles were present in the minds oi the designer of each of these weapons.

I come now to consider the sword as a weapon for thrusting; models of hand-thrusting tools are so numerous that it is difficult to choose from them. The bradawl, the gimlet, the needle, the dinner-fork; any of these will serve for illustration; with regard to the method of their progression they may be considered as a very acute wedge entering obliquely.

The thrust has always been considered in swordsmanship as infinitely preferable to the cut, and the reason is as old as one of the first definitions of Euclid—that "a straight line is the shortest way between any two points." In making a thrust the sword moves in a straight line, and in making a cut it moves in a circle, and of course the thrust is much quicker. You will see in the sketch representing two men in the position of guard, Plate II. fig. 23, that the distance which the figure A with the straight sword has to traverse in making a thrust is less by two-thirds than the distance which the figure B must traverse in making a cut; therefore, if they move with equal velocity, the thrust will reach its mark in one-third of the time, because the one traverses the diameter and the other the circumference of a similar circle.

In figs. 24 to 30 you have various sections of thrusting blades. Fig. 24 is the oldest form, known as the Saxon, or among workmen as the "latchen" blade. You see this form in many of the Toledo and early rapier blades; it consists of two obtuse angled wedges joined at the back, and is sufficiently strong and stiff, but very heavy. Two methods of lightening it by grooving are shown in the next two figures, Nos. 25 and 26. The third (No. 27) is the Biscayan form, with three deep grooves, better known as the French duelling rapier. Technically, either of the former forms is superior to this, as there is very great difficulty in getting these blades straight and of even temper; so much so, that I have never

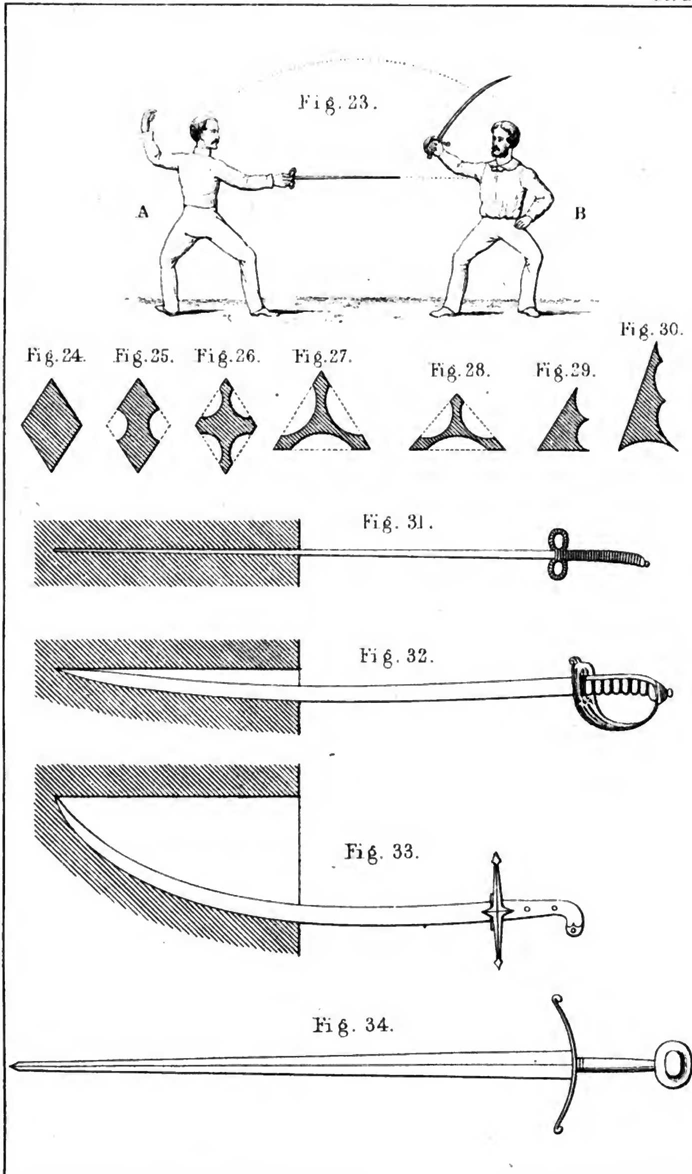
Fig. 23.
A
B
Fig. 24.
Fig. 25.
Fig. 26.
Fig. 27.
Fig. 28.
Fig. 29.
Fig. 30.
Fig. 31.
Fig. 32.
Fig. 33.
Fig. 34.

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seen one of these three-cornered rapier blades which was not either soft or crooked. Theoretically, however, the shape is a very good one. Fig. 29 is a section of a very curious thrusting blade. It is probably an experimental sword of the date of 1810 to 1814, and is from the manufactory of Klingenthal. I have seen a great number of these experimental blades, many of which are very curious and suggestive. Here, for instance (fig. 29), is an attempt to give cutting power to a rapier blade, but these angles being very obtuse, have scarcely any effect in a cut. The next, fig. 30, is an improvement on the same form; it cuts much better; but the defect in both these swords is, that they have a tendency to turn over in the hand and to spring at the flat side on the point meeting with the least resistance.

Of course the proper shape for a thrusting sword is pre-eminently straight. As an illustration of the difference in this respect I have a diagram (figs. 31 to 33) showing the effect of a straight thrust into a block of wood with a straight sword, with a slightly curved (regulation) blade, and with a sword of the tulwar or cimeter curve. You see the straight sword moving in a straight line makes a hole exactly the size of the blade; the slightly-curved sword moving in a straight line cuts a hole of about double the width of the blade; but the cimeter blade thrust into the same depth makes a hole five or six times the width of the blade itself, and of course meets with six times the resistance to its penetration. You see, therefore, how difficult it is to use one of these curved blades for the straight thrust. This difficulty probably suggested a method of thrusting which is styled the curved thrust, in which the blade is propelled, not in a straight line, but in an arc of a circle more or less curved to correspond with the blade. The arm makes this curvilinear or cycloidal movement very readily, and it is doubtless the best way of using a curved blade for thrusting at all, but it is open to the objection that the space traversed (as in the cut) is longer than is necessary to reach the object, and that it cannot be used with the "lunge," so as to throw the force of the body into the attack. Like the "thrusting cut," this attack is better suited for horseback than for foot, and in any case it is inferior to the straight thrust. However, this idea of the curved thrust was at one time considered very valuable, and Colonel Marey, of the French army, in an elaborate and excellent work on swords, published at Strasbourg in 1841, went so far as to suggest that the shape of the yataghan, which is excellent as a cutting weapon, and for thrusting can be used with considerable effect in this way, should be adopted as the regulation Infantry sword. It was adopted and tried to a certain extent in the French service, and finally, just as the French were beginning to abandon it, it was adopted partially in England. It is the parent of the present short Enfield sword bayonet, and, as you will see by comparing the two, it has been cleverly modified so as to lose all the distinctive excellences of its original. The beautiful curved line of the yatághan, so accurately coinciding with the motion of the wrist in cutting, is completely lost, and it is applied to the worst possible use in being placed at the end of the gun, where the weight forward, which is so valuable in cutting by the hand, renders it, when placed upon the gun-top, heavy and unmanageable. It is very much inferior to the ordinary bayonet, and it has frequently caused surprise how it came to be adopted here. The reason is simply that it had been tried in France. It has now been abandoned there, and I imagine that we shall

soon have to abandon it in the same way, as it is vastly inferior as a thrusting weapon to the ordinary bayonet, and the power of making a cut is poorly purchased by the loss of all manageability in the arm.

The only other point we have to consider is the sword in its use for guarding. In considering this point we must recollect that guarding is very rarely practised in Eastern swordsmanship. The Eastern soldier is taught to use his sword as a weapon of attack only, and is well provided with steel gauntlets, helmet, and shield to resist a cut. He is therefore contented with a very small guard to his sword, and prefers what we consider a very top-heavy "balance." But we have to contrive a sword that shall be useful in guarding as well as in cutting or thrusting, and to do this we must modify it considerably. The best cutting sword, if it were not necessary to "recover" to guard with it, would be the axe, and the only reason why we want it modified into the form of a sword at all is, that we may be able to use it to defend ourselves as well as to attack our adversary.

The "balance" of a sword, of which I have spoken, is essential for guarding, and for guarding only. The stiffer and heavier a blade is, the better is it adapted for both cutting and thrusting, and it is only when you want to "recover to guard" that it becomes necessary to have it light or elastic. In the old Highland claymore you will find the hand so cramped that it is not possible to form a guard with it truly and readily; this is explained by the fact that the claymore was not used for guarding. The defence of the Highlander was entrusted to the dirk and target on the left arm.

The principal requisite for a good hilt is that it should have as much guard as possible without cramping the hand. The claymore, as I have said, is deficient in this respect. In the Eastern cimeter, which is not intended for guarding, the only protection to the hand is a simple crutch. Most modern swords are defective in the hilt. The Light Cavalry regulation sword has a very bad guard indeed. There is no protection against a thrust, and the whole inner line of the wrist is exposed. The whole weight being on one side of the blade, it has a tendency to turn over in that direction, and in using it you have to exert and waste a certain amount of force to overcome that tendency. The regulation Infantry sword has a much better guard, but it is defective on account of the metal of which it is made, which is liable to be cut through or broken by a fall. The Engineers' is a very good guard, as is also the heavy Cavalry, but both have the defect of being over-balanced, *i.e.* heavier on one side than on the other. A sword I have lately made for India is free from this defect, as the sword will really balance along the edge, the guard being equal on each side. It is only fair to say that this hilt was suggested to me by the straight Mahratta sword I have so often referred to. You will doubtless be amused at me when I say that this sword shows more thought in the contriver than any other with which I am acquainted, and the swordsman may obtain many useful hints from it. Here is an officer's regulation Infantry sword of twenty or twenty-five years' ago. It is a specimen, I believe, of the worst possible arrangement of hilt, blade, and shape, that could possibly be contrived. It is crooked, but has no regular curve; is wrongly mounted for thrusting and wrongly shaped for cutting. The hilt is so flimsy as to be no protection for the hand, and it is made of bad

metal badly tempered. If you ask me how such a model came to be adopted, I can only answer by a supposition. At that time the three principal purveyors of swords to the British army were a tailor, a gold-laceman, and a hatter. I can only suppose that the tailor was the first consulted; if his production was unsatisfactory, the pattern was referred to the laceman; and finally the hatter was called in, who put the crowning touch to the whole.

There are some very curious old swords, both European and Eastern, which I dare say most of my hearers have met with, in which the back of the blade is made hollow, and mercury, placed in the hilt, is carried towards the point in cutting, thus adding to the force of the cut. You will see at once that, though this added to the force of the blow, the additional weight rendered the sword topheavy, and told against the swordsman, if his cut were parried and he had to recover to guard himself. In the same way some of the German headsmen's swords were made with a ball of steel to slide down the blade and add increased force to the cut. Here is a curious instance of what I mentioned to you with regard to the effect of over-weighting. It is a sword weighing 6½ lbs.; it originally weighed 9 lbs., but has been considerably lightened. It was made for an officer in a cavalry regiment, who thought it would strengthen his wrist to use it in post practice. The result is that no living man can cut with it. You can lift it up, and let it drop on any object you please, but beyond this you cannot go. The weight is so great that it is impossible to give it any velocity, and its cutting power is therefore nil. A very simple test shows this. It is easy enough to cut a copper penny in half by a quick blow with a bowie or hunting knife. I have tried to do the same thing with this sword, and hack and hammer as I may, I cannot get it to go through the penny. With the knife I can give a high velocity; with the sword I can give none at all, and so I can do nothing with it.

I think these are the only points to which I have to call your attention, and, as I have already detained you beyond the allotted time, I will conclude by thanking you for the kind attention with which you have listened to me.

The Chairman.—I am sure we are very much obliged, Mr. Latham, for the interesting and instructive lesson which you have given us. I thought it was a very dry subject, and was not at all prepared for anything so interesting or instructive as this. It shows that you have thoroughly studied the subject, and have made yourself completely conversant with it.

Captain Burgess.—Will you kindly make a few remarks upon that curious sword of the time of Edward III.? (Plate II. fig. 34).*

The Chairman.—You might tell us what was the effect of that heavy sword upon the wielder's wrist.

Mr. Latham.—I believe he found he could not use it; in fact, that he could hardly lift it, or make a cut with it. I ought to have made a few remarks upon this curious old sword. You will see from its tremendous weight that it was intended for a time when swordsmen had to deal with iron-plated men, as we have with iron-plated vessels, and you see how they solved the very question we are debating now. They got the heaviest weight they could, and they put as much force behind it as they could

* Bequeathed to the Institution by the late Walter Hawkins, Esq., F.S.A.—Ed.

possibly give—exactly the same thing we are now doing in our experiments with artillery against iron-plated ships.

Captain SELWYN, R.N.—There are one or two questions I wish to ask Mr. Latham, for the benefit of the naval branch of the profession. One is, whether it has occurred to him that the use of the heavy knob on the guard in that antique sword, which we have just been looking at, has anything to do with the old term of pommelling one's enemy? As Jack has often been known, in a press of men, after having got up his sword-arm and being unable to get it down again, to use the hilt of his cutlass, and knock his enemy's teeth down his throat; so may not the ancient knight have used that sword to pommel his enemies, after using the sword to cut him down? I would also ask whether his attention has been drawn to the peculiarity of Lord Cochrane's mode of arming his seamen for boarding? He fastened bayonets to their left arms, with the points projecting beyond the hand, and then armed them only with cutlasses, telling them to go and take the enemy. Of course, the bayonet formed a perfect guard, tied as it was along the outside of the arm, with the points projecting about 6 inches. It enabled Lord Cochrane to take the Spanish frigate in the way he did, from under the batteries of Callao. The last thing I beg to ask is, if, by any effort of art, Mr. Latham can give us a weapon which will enable the seaman to feel a little more secure. Seamen begin to feel that they have lost their confidence now that plated ships have come into action. We are in that state, that, with the very hard shells ships have now got, it will be utterly impossible to hope that swords will ever come into play; and, if Mr. Latham can only suggest some means of offence, I think we should be delighted. For the ancients and for cavalry, swords may be possible, but not for seamen.

Mr. LATHAM.—With regard to Captain Selwyn's remark about the pommel of this sword suggesting the use of the term "pommelling," I think it is very likely. It is a happy idea, and there are many etymological derivations much more far-fetched. The idea of strapping the bayonet to the arm was perhaps suggested to Lord Dundonald, who was a Scotchman, by the method of using the dirk with the target. The thumb being placed on the hilt of the dirk, the point projected about an inch beyond the elbow; the target was used for parrying, and the return given with the dirk. I am not sufficiently acquainted with the construction of the new iron ships to give an exact reply to the third question. But, from the accounts we have, it seems to me that the only way to encounter an enemy of this description is to attack him as you would a wasp's nest; smother him by stopping up his funnel and hatches. I am aware that a lecture of this kind on the use of swords may seem to have more of an antiquarian than of a practical interest in the present day. At the same time the sword is the *ultima ratio*—the best weapon for hand-to-hand encounter, and to hand-to-hand encounter it must come at last. If we go on improving our armour at such a rate that we cannot hurt each other while we keep within our vessels, the only means of deciding the question will be to come out of them; and this may lead to the old system of man to man being revived, and the shape and use of the sword become again a subject of some importance even in naval warfare.

PRESENT CONDITION OF OUR CAVALRY; WITH SOME SUGGESTIONS AS TO THE PRACTICABILITY OF INCREASING ITS EFFICIENCY IN THE FIELD.*

By Major Alfred Stovell Jones, V.C.; D.A.Q.M.G., Cape of Good Hope.

While the Artillery and Infantry of all armies have passed, during late years, through the most extensive changes in organization and equipment, and engineers have modified the arrangements of defence to meet these changes in offensive warfare, the Cavalry service has alone stood still, or nearly so, when its progress in the march of improvement is compared with that of the other arms.

It is true that the Emperor Napoleon is understood to have turned his attention to Cavalry at Chalons, and that a commission has been sitting for some months at the Horse Guards to consider and report upon our Cavalry; but, in the first place, it will hardly be creditable to us as a nation if we allow the French to show our Cavalry the way; and secondly, we shall be expecting too much from our authorities, if we leave to them the task of originating or inventing the required improvements.

The authorities at the Horse Guards and the War Office did not invent the Enfield rifle, or the Armstrong gun; they confine their attention to their own province, consider the merits of proposed improvements, and adopt such as they approve.

It is the object therefore of these pages to draw the attention of Cavalry officers and others to two questions which are constantly occuring to the mind of every one who looks forward to the prospect of future wars.

1st. Will Cavalry, equipped and organized as at present, retain the same high relative position in future wars which it has held in past times?

2nd. If not—what changes must be introduced in order to restore in favour of Cavalry the balance against rifles and rifled cannon?

Let us consider the first question with reference to the duties of Cavalry in the field as enumerated below.

Heavy Cavalry	Charge against Cavalry. " " Infantry. " " Artillery.	Light Cavalry	Outpost duty. Reconnoitring.

In the first division of Heavy Cavalry duties, viz., the charge against Cavalry, the conditions are what they have always been, and victory will remain with that side which can bring up the last reserve, rides harder, has better bred or more powerful horses, or which is led by better officers, than the other.

One or a combination of these advantages may carry the day, but, alas! how seldom is an opportunity for this glorious duel afforded by modern warfare.

* Communicated May 29, 1862.—Ed.

In the second and third divisions of Heavy Cavalry duties, however, the case has been materially altered, to the disadvantage of Cavalry, by the introduction of new weapons, and improved projectiles, inasmuch as Infantry and Artillery are no longer nearly harmless at 200 and 400 yards distance respectively, as formerly the case.

The details of both Artillery and Infantry rifle practice are too well known to need more than a simple reference to them here in support of this conclusion.

It is true that the superior precision and range of the modern rifles and shells will not be felt very much in the actual advance to the attack by Cavalry charging Infantry or Artillery, because the necessity for constant re-adjustment of sights and time-fuses will nullify their effects upon a rapid advance; but no extensive formation or deployment of Cavalry can take place under a heavy fire of segment shells and conical bullets.

It appears certain, unless some peculiarly advantageous ground permits the formation under cover within reach of the enemy, that the Cavalry must advance in line over far too much ground to admit of its preserving anything like steadiness in the attack; besides which, the intended point of attack, and probably also the whole force, and reserve, prepared for the charge, will be patent to the enemy in time to enable him to concentrate his force on the menaced point.

This leads to the conclusion that, for the future, Cavalry must be banished from the first line—it must be kept strictly under cover in the second line, until an opportunity occurs for employing it in actual collision with the enemy, and must then be brought rapidly up and formed on the move. Its very existence will depend upon its mobility. How far this essential quality is compatible with our present equipment and system of drill, is known to every one who has endeavoured to get the simplest manœuvre of the drill book performed with the requisite steadiness on the move by even one squadron, amidst the noise and confusion of action. Impatient men and fretful horses in the rear rank, and the plunges of wounded ones in front, together with the loss of telling-off consequent upon casualties, are formidable obstacles to a steady formation, and often occupy the attention of the leaders, at the time when it is equally necessary for them to be watching the enemy.

So much for the prospects of the Heavies in future campaigns; let us now turn to the Light Cavalry, and see how the case stands for that branch of the service.

The duties of outposts and reconnaissance are among the most important of those for whose performance a general in the field has to provide, and hitherto, whenever the country has been even moderately open, these duties have been for the most part performed by Light Cavalry.

The daily comfort of an army during the whole campaign, as well as the success of every enterprise, is so dependent upon the manner in which these duties are carried on, that it would surely be advisable to equip and organize the force to which their performance is entrusted with a view specially to those duties, and not to expect it to undertake, or be prepared for, other duties which demand different qualifications.

Heavy Cavalry for the charge should be organized on the principle that each squadron be considered as a living projectile, which must be carefully

preserved in condition and weight, until the moment at which it is to be hurled against the enemy: every thing should be done to consolidate and bind it together; it should be nursed as much as possible, and be brought into action in the very highest state of efficiency for one short gallop. One discharge of such projectiles, launched at the right instant, may change the fate of a battle, or complete the destruction of the enemy.

Light Cavalry, which, on the contrary, is valuable in proportion to the individual excellence of its men and horses, should be composed of short, active, and intelligent men, mounted upon wiry enduring little horses, and trained with more individual self-reliance, to take their own line across country, jump or creep wherever their horses can live, rally for a short rush, or disperse and baffle their pursuers by flight wherever they appear too numerous, but always ready to return to the worry when a chance is open to them.

We know that division of labour is productive of greater efficiency in every trade, and it seems impossible that the same men and horses can be trained to the performance of duties so much opposed to each other as those above described, with any prospect of combining the highest state of efficiency in each; nevertheless, in our service it has been ordained, from motives of economy, that the Light Cavalry shall be equal to the charge in line.

The result of this policy has been, as might have been expected, that we have sacrificed complete efficiency as Light Cavalry to gain a measure of success as Heavy; and, though in all former wars this makeshift for a perfect Light Cavalry has done the work required of it, and has beaten the best Heavy Cavalry that could be brought against it, yet this success has been due to national advantages rather than to the system itself. We have beaten our enemies because our Cavalry was made of better stuff than theirs, rather than because we had cut it out in better fashion.

In former wars Light Cavalry could gallop up and establish its outposts, without much risk, within some 200 yards from those of the enemy; but in future it is to be presumed that he will have at least some rifles on his advance posts, which will demand respect at treble that distance.

The difficulty of obtaining information was always great, but what will it be in future?

It appears that it will be difficult for our present style of dragoon to approach near enough to the enemy even to ascertain the direction of his line of outposts, and he will have little chance indeed if he ventures, as he used often to do, within that line, trusting to the speed of his horse for escape in case of being viewed.

In future, outposts will probably be formed by troops organized and equipped to seize and maintain positions by long range and accuracy of fire.

Our cavalry are to be furnished with breech-loading rifled carbines and rifled pistols; but there are some very serious objections to this sweeping change.

1st. It will be impossible to teach cavalry as a body to make anything like decent practice while mounted.

What a ludicrous exhibition is always made when Cavalry send out their skirmishers, nine out of ten of whose horses feel like fish out of water

until they rejoin their squadrons; many of them are seen to wheel about, or at any rate throw up their heads and jump at every discharge of their riders' firearms, and some even can hardly be induced to leave the ranks until long after the sound for "skirmishers."

2nd. All officers who have served with Cavalry in the field, will allow that the men are far too fond of applying to their carbine buckets and holsters, even when they know, or ought to do, that the arms they contain will hardly hit a haystack, and there is surely some reason to dread that this tendency of the Dragoon to place too much reliance on his firearm will be increased by supplying him with a superior weapon of that kind.

Our present Dragoon can only render himself formidable to his enemies by the speed of his horse, and the lance or sword in his hand.

He must seek to close with his enemy or he will be worthless, for, should he attempt to play at long bowls, he will inevitably find his master at that game. Some few men per squadron might be armed with rifled carbines, to dismount and use them occasionally; but these men should invariably be good marksmen, and men who can thoroughly be depended upon; the rest of the squadron will do much better without any firearms at all, unless they can be trusted with a revolver in their belts, to be used only for their individual self-defence, in case of being dismounted in a *mêlée*.

It is but natural to expect that rifles will in future be used by the advanced guards and outposts of enemies, and such being the case it is hardly likely that a less distance than about 900 yards will intervene between those of two hostile armies.

The best of our Cavalry carbines, however, will range with good effect but half that distance, and, when we consider what a conspicuous target one of our present videttes would make, it appears that our present Light Cavalry must be beaten out of the field by any modern Light Infantry which can be pushed up to the outposts by an enemy.

Thus we arrive at the conclusion, with all due respect to our Light Cavalry, that its right occupation is gone. It, however, having been half organized as Heavy Cavalry, we need not throw it away, for we have not come to the same conclusion with regard to the duties of the Heavies, although, there even, we cannot but recognise the necessity for introducing some changes.

"Tactics," said the first Napoleon "must be changed every ten years;" how much more does the introduction of altogether new weapons appear to demand a change of organization and equipment!

Before such deep radical changes as those which appear desirable (if the above is a fair statement of the prospects of our present Cavalry) can be safely introduced, there should be a wide-spread conviction, gradually diffused through the whole body which is to undergo change, that such change is necessary.

No healthy reform can be introduced from without, before the necessity for it has been recognised from within, for there is a rooted conservative feeling in all human nature, which rebels against change, silently it may be, but often so effectually as to nullify all good which might have resulted from a willing response on the part of subordinates to the noblest designs of their superiors.

It is in the hope of contributing in some degree to this preparation for reform, that we have opened this subject, and, since writing the above, we have noticed with pleasure a review of the work of Colonel D'Azemar, entitled "The Future of Cavalry," in the U. S. Magazine.

This shows that the subject is in course of ventilation, and it is our firm conviction that Cavalry will eventually recover its relative position to the other arms.

It may require a campaign or more to bring about this result, but the earlier we recognise the necessity for change, the more time we shall have to consider and mature the means of introducing it; let it be done, if possible, gradually during peace, rather than hastily in war.

Having now adduced what appear to us valid arguments for replying in the negative to the first question we proposed to ourselves, we will pass on to the second, which is by far the most difficult part of the subject, for it is one thing to find fault with a system, and altogether another to propose one which shall work better. The one is constantly done and often reasonably, but the other, seldom, if ever, with complete success.

We will do the best we can, however, and perhaps our example may induce others to come forward to correct our errors, and make their own suggestions as to "what changes must be introduced, in order to restore the balance against rifles and rifled cannon."

In the first place, then, it follows, from what has been said about the duties of Heavy and Light Cavalry, that the distinction between these two branches of the service, at present only nominal, should be revived in full force.

Let us consider how each of these arms may be reorganized, with a view to giving each of them the highest possible qualifications for its own peculiar class of duties.

First, then, for Heavy Cavalry; "mobility" is the great desideratum. There is no doubt that having good leaders, and plenty of them, is a principal element of success in Cavalry action: without them the best Cavalry become like a flock of sheep. Every man in a squadron should be under the eye and within the reach of its leaders.

Our present system places one half of the men in a rear rank, where they are quite out of reach, and we have to place serrefiles, when we have them, in a third rank, to watch and control this rear rank, which has been alluded to above as useless, and prejudicial to the free working of the front rank. On a peace field-day the serrefiles, with the assistance of troop and regimental sergeants major, and the adjutant, may succeed in keeping some order in the rear, but on service their assistance is rarely available. The objection to Cavalry rear ranks has been recognised for many years by some of the best Cavalry officers, and the system of rank entire was adopted with great success by General Bacon in the Portuguese service, in 1833, and following years. General Bacon had many supporters, and much was written in favour of his system, both at the time he adopted it and in 1854-5, when Colonel Beamish published his remarks, "Uses and Application of Cavalry in War," with copious annotations; yet, as Lord William Russell says, in one of the letters published in that work, "the Duke of Wellington is in our favour, but the prejudices of Cavalry officers

are difficult to overcome," and the old system stands its ground. Some of the remarks of the late Duke of Wellington, upon using Cavalry in rank entire, are so pertinent and conclusive in favour of the system, that we cannot resist the temptation of quoting the following extracts from his Grace's letter to Lord William Russell, published in full in Colonel Beamish's work.

"The rear rank does not strengthen the front rank as the centre and rear ranks do the front rank of the Infantry. The rear rank of the Cavalry can augment the activity or even the means of attack of the front rank, *only by a movement of disorder*.

"If, then, the attack of the front rank should fail, and it should be necessary to retire, the second or rear rank is too close to be able to sustain the attack or to restore order.

"The second rank must be involved in the defeat and confusion, and the whole must depend upon some other body, Cavalry or Infantry, in reserve, to receive and protect the fugitives.

"I have already stated that the second or rear rank can augment the means of the first rank only by a movement of disorder; this is peculiarly the case if the attack should be successful. In all these cases, the second rank, at a distance sufficiently great to avoid being involved in the confusion of the attack of the front rank, whether successful or otherwise, could aid in the attack, or, if necessary, cover the retreat of the Cavalry as a body, while, by the absence of all impediments from the closeness of the rear rank, the activity of the front rank would be increased.

* * * * * *

"I conceive that the one-rank system would require a change, not only in the discipline, but in the organisation, of the Cavalry. If I am not mistaken it would render the use of Cavalry in an army *much more general than it is at present*."

The Cavalry Brigade at Umballa, in India, was manœuvred on the system of rank entire by Colonel Grant, now Sir Hope Grant, K.C.B., in the years 1855-56, and, in spite of the disadvantage that the second line was only formed on the parade by increasing the distance of the rear rank of each squadron, and placing officers and non-commissioned officers in front of it as squadron and troop leaders, instead of being composed of distinct squadrons, as it would be if the system were fully adopted, it nevertheless appeared to work well.

Subsequently, in the operations before Delhi, the officers of the 9th Lancers, who had profited by the lessons learnt at these field days of the previous drill season, found several opportunities of employing the rank-entire system before the enemy. On one occasion, 4th July, 1857, it fell to the lot of one squadron, 9th Lancers, to have to cover the retreat of a small force of Infantry which, overpowered by numbers, had orders to fall back across a mile or so of open, to cross a bridge, and then defend a canal until reinforcements could arrive.

The squadron, formed in the usual manner, was hard pressed by a large force of the enemy's Cavalry, whose front was covered with skirmishers, who threatened, by out-flanking the squadron, to cut it off from the bridge.

The officer in command of the squadron, seeing his danger, hit upon

the plan of deploying its rear rank to form a second squadron, and extend his front; this move had a visible effect in checking the enemy, and he was then able to retire by alternate squadrons, at the walk, until he reached the bridge, just as the last man of the Infantry had defiled across.

A few months later, the same officer had cause to regret that the system of rank entire was not in force, when, having to form a troop of 23 men only from single file, in front of two squadrons of the enemy advancing at a trot to attack him, he had not time to get even this small force into a single rank, and was consequently obliged to perform his charge in two ranks against the leading squadron of the enemy, when it outflanked his troop by more than two-thirds its front.

It may be objected that the weight of two ranks was not so necessary in the cases above cited as it may be in others, but then we would respect the words of the Iron Duke that the rear rank can only aid the front rank by a movement of disorder, and would be more usefully employed if brought up under its own leaders to succeed the front rank in its career.

If, however, weight is desired, the second line of rank entire squadron may be brought up to half a horse's length at the moment of action; its leaders moving out to the flanks.

There are two other impediments to mobility in our present system, viz. pivot flanks, with all their attendant evils of inverted lines and the movement by threes.

Nothing can contribute more to mobility than simplicity of drill, and nothing can be more complex than our system of pivot flanks, a due attention to which must occupy every faculty of Cavalry leaders, and leave them little leisure to look out for the nature of the ground and the condition of the enemy, which are all-important points.

In the movement by threes, as 12 inches only is allowed from nose to croup, opening out is almost inevitable, and the squadrons thereby lose their solidity; the closing in to dress, thereby rendered necessary when the squadron is fronted, appears to us a far greater evil than the appearance of daylight, which is urged as an objection to rank-entire squadrons.

In forming threes on the halt to a flank the reining back of the flank horses, particularly in deep ground, is apt to produce vice by unnecessarily irritating the animals, even when their riders have good hands, which is an unusually favourable condition.

Having stated the above objections to our present drill, we will proceed to suggest a few principles upon which a new one might be built up.

1st. Let the regiments be sized, as to men and horses, by squadrons, each squadron being of the ordinary strength of a troop, with one additional lieutenant.

2nd. Form the squadrons in rank entire with their own captains and lieutenants as leaders, placed, as at present, half a horse's length in front.

3rd. Number off, and let the rank consist of a number divisible by 8, *i. e.* be 24, 32, 40, 48, 56, 64, 72, &c., &c., the odd, 1, 2 . . . 6, 7 men, if there be any left over, forming a second supernumerary rank, to ride in rear of the squadron under charge of the serjeant-major, and fall into the rank one by one as casualties occur, to keep up the charmed number divisible by 8.

4th. Divide each of the squadrons into two troops of equal strength, and tell them off by *fours* from their inner flanks.

5th. Make any number of complete "fours" which is nearest the half troop, into divisions (either flank or centre divisions may be the strongest.)

6th. Let the fours wheel invariably forward on the horses of the named flank.

The arguments in support of these principles are briefly as follow:

1st. The regiment is sized by squadrons, in order to make the parts of each perfectly interchangeable, so that it may be indifferent what part of the squadron any man and horse may be placed in.

2nd. The advantage of keeping each squadron always under its own officers, both in the field and for interior economy, must be self-evident, and needs no remark.

3rd. The adoption of these numbers for the squadron seems desirable in order that each troop may be composed of an equal number of complete fours. The parts of the squadron may then be wheeled about in any manner, and still retain the telling-off by fours intact until casualties occur; these can be filled up at once by a man from the supernumerary rank moving up as a stop-gap while any of that rank remain, and, when it is expended, the squadrons can be re-told off on the same principle as at first, the seven men rendered supernumeraries reining back accordingly.

4th. The superiority of "fours" over "threes" for the flank movements of Cavalry consists in the greater freedom of movement gained by allowing 1 yard from nose to croup, instead of 12 inches, which is the theoretical distance allowed in "threes."

Practically, indeed, a column of threes always opens out more or less on the march, from the difficulty of keeping horses up so close, and when fronted closing must ensue; whereas in fours, since a horse is about 8 feet long, and 4 horses in line show a front of 12 feet, when wheeled into column, there is a theoretical distance of 4 feet available, which allows a margin of 1 foot to spare, when the rule of 1 yard from nose to croup is observed. Another reason for objecting to such a close column as that of threes, is the liability to accidents so often incurred, from horses treading on the heels of those in front of them.

All wheels of fours being performed on the flank, it is only necessary for the flank men of each four (that is, those who number off 1 and 4) to remember their telling-off, because the wheeling flank man brings the two centre ones round with him. The flank fours of divisions can easily remember that they are such, and this is all that is required of the men in the ranks.

This system of "fours" has been tested, and is in practice, in the French Cavalry.

5th. It will be observed, that, as the proposed divisions will not be necessarily of equal strength, there may be overlapping of some divisions over others when they are wheeled into column, but, as it is provided in the 5th principle that the divisions shall consist of numbers of complete "fours," as nearly as possible equal to the numerical half of the troop, it is evident that no division in a squadron can exceed any other by more than four men.

Instead of the old rule of "when right is in front, left is the pivot," we

propose the general one, "that covering be preserved by that flank on which the wheel into column was performed, until it is ordered to be changed."

The necessity for regarding pivot flanks having passed away with rear ranks, and squadrons which can be clubbed by putting the proper right troop on the actual left of the squadron, it at once follows that a column may be wheeled into line indifferently to either flank as required; in ordinary circumstances perhaps it would be well to order the covering to be changed, a few seconds before wheeling into line to the other flank, and upon such a caution the leaders of weak divisions (the case of a column of divisions) would incline to take up the new covering, in order to ensure a steady wheel; but such change of covering is by no means necessary even in a column of unequal divisions, for the wheeling flanks of the weak divisions will come round more quickly than those of the stronger ones, and they will have time, after completing their own wheel, to move steadily up into line with the stronger ones, as quickly as the latter can complete their wheel.

The distance they would have to move up being only four yards, this can hardly cause any great unsteadiness, and, as has been said before, it can be avoided altogether by changing the covering a few seconds before the wheel.

It is well known that the advance in line is the most important movement which Cavalry can have to perform; all other movements are preparatory to it, and lead up to this final advance, which is to end in the decisive charge, the failure or success of which principally depends upon the order and regularity of the line at the moment of impact upon the enemy.

The preservation of order up to this moment is the hardest duty that squadron and troop leaders have to perform; the squadron leader especially should have a steady horse well in hand, and it is essential that the centre man of the squadron follow his lead faithfully and steadily, at half a horse's length distance; but when a rear rank is pressing upon his horse's tail, and a horse edging up against his thigh on either side, it is often more than this man can do to avoid treading on his officer's horse's heels, and thereby rendering him hopelessly unsteady for that day at least, if not for the rest of his life, as a charger.

The abolition of rear ranks would most materially diminish the embarrassments of this hardly-used and valuable soldier, whose duty after that of the squadron leader is certainly most important to the welfare of the squadron; but, as his duties will still be most important, it is but reasonable to pick for this place the best rider of the squadron, and mount him on the steadiest horse.

In the interchangeable squadron we have described above, we would place him between the two troops when the squadron is in line, and make him quite independent of its telling-off.

When the line breaks into column, this man or non-commissioned officer (as he will possibly hold the rank of sergeant) will move independently and take up the position of squadron marker, whose duties he can always perform, and, when line is re-formed, he will come up to his original place, which will be kept vacant for him by the flank men of troops.

On the wheel about by "fours," he will move out to the front, and turn about to resume his post in the ranks, and lead the line to the rear, when it is ordered to retire.

A regiment of the present establishment, formed on the principles above sketched out, would parade in two lines of four squadrons each, at a distance, generally speaking, of the front of a squadron, and an interval between the lines.

The second line would be commanded by the major, to repeat the words of command, which may be the same for both lines.

Every movement from line into column (open or close) could be performed upon any named point with the utmost celerity, and the column would deploy or form line by the command, "To the right or left of the front ——" as desired.

The simplicity of the proposed system of drill consists in this: that neither officer nor man is burdened with a string of things to be remembered, and therefore everybody's wits are available for more important employments.

After any change in the order of squadrons, the leaders will number off without word of command, and then if the men who are flanks of troops, divisions, and fours, can only recollect that they are such, and know their right hands from their left, there is no more to be thought of, and there can be no excuse for the slightest confusion.

Such is the outline of changes we propose for giving mobility to Heavy Cavalry, and if such a system of drill were adopted for all our present Cavalry, heavy and light, the distinction between which, is rather nominal than real, we are convinced that our squadrons could be brought up even to the bayonets of a square, without sustaining much more loss than they were liable to in the days of *Brown Bess.*

How far it is possible for Cavalry to break a square of good Infantry, unshaken by Artillery fire, has been always a disputed point, and all Cavalry enthusiasts, we doubt not, will bear with us while we offer a few suggestions which we trust may tend to set the question at rest in favour of Cavalry in future wars.

First then, such a charge must chiefly depend for success on its momentum, measured, just as that of any other projectile, by its weight multiplied into its velocity. Sir W. Armstrong has succeeded in smashing strong iron plates by increasing momentum, and changing the form of his inanimate projectiles, and let us be encouraged thereby to look for similar results from our endeavours to apply like remedies to the deficiencies which have made our Cavalry break up before the bayonets of a square, as the old shot have done against 4½ inch plates.

The momentum then of a charge being the weight of all the men and horses who are effectively employed, multiplied by the speed at which the squadrons are moving at the instant of collision, it could be increased by augmenting either of these terms, the other remaining the same or being also augmented. Weight however can only be advantageously augmented by obtaining horses of greater power in muscular development; any other increase of weight will only produce a more than compensating loss of speed. Moreover, it has been found that the breaching power of projectiles is to be measured by their weight multiplied by the *square* of their velocity; consequently, speed is by far the most important term in the calculation, and what is true with regard to the inanimate projectile must be equally so with squadrons of Heavy Cavalry, if rightly employed.

We should therefore endeavour to reduce all that the horses have to carry which does not tend to produce motion, to a minimum, and increase their muscular power to a maximum—accordingly we would reduce the weight of Cavalry men as much as possible. The terms of enlistment should be such, that on a man's attaining a fixed weight (say 12 stone) he should be at once transferred to the Infantry of the Line, unless he were found to possess qualities which were considered to compensate for the evil of his weight.

Men of 10 stone are strong enough, if well made, to manage a horse and to use a lance or sword with effect: every pound therefore in excess of that weight is prejudicial, because it will diminish the speed of the horse. In racing, 7 lbs. is often considered equal to "a distance," and yet we now put more than double that weight in the shape of a valise over the Cavalry horse's loins.

Would it not be better to attach transport, in the shape of a cart or a few bât horses, to each squadron, for the purpose of carrying all in the way of clothes and food required by both men and horses?

The transport could always accompany the squadron until the actual combat, if the Cavalry were properly husbanded and kept out of fire, and then, if the attack should succeed, it would be easy for the transport to rejoin, and, should it fail, the loss of baggage ought to be a small consideration, for Cavalry once sent into action should be considered as sacrificed for ever, unless its attack prove successful. There can never be half measures with such a force as this, and the general who employs it, should be well satisfied that the occasion on which he does so, is important enough to warrant the risk of its total loss, or else he should not send it into action at all.

This is the reason why so few good Cavalry leaders can be found, because the union of caution and reckless enthusiastic energy seldom falls to the lot of the same individual, and the lack of either of these qualities is generally fatal to the other. Caution is most desirable up to the point of engaging the enemy, and then utter fearlessness of consequences must take its place, to carry out the plan which has been carefully matured.

With regard to weapons for Heavy Cavalry, none can equal the lance for general purposes, but it should be backed up by a good cut-and-thrust sword.

Among lances, the Indian hog-spear bears off the palm, from its length and lightness, and is infinitely superior to the new lance lately adopted into our service, whose thrusts can be easily parried. The lance should be well up under the arm, wedged between it and the body throughout its thrust, and, when held in this manner, a round parry, produced by the turning of the whole body above the hips, will sweep down anything the lance may come in contact with.

Lances should be 11 feet long, and with such there can be no difficulty in reaching over the bayonets of Infantry.

If a few of the kneeling rank can be speared, the lances may be abandoned, and the squadron, pressing in with their swords over the wounded men, may soon complete the destruction of the square. We have already pointed out some of the objections to carbines, so far at least as regards heavy Cavalry, so of course we propose to relieve the horses of

this dead weight. If the valises be carried in the squadron cart, saddles may be reduced both in size and weight.

Cruppers, too, may be discarded with great advantage; and after all these changes we may hope to bring our Heavy Cavalry into the field, bearing an average weight of 14 stone per horse, instead of 18 stone 4 lbs. which is now the average of our Light Dragoons.

The increase of speed which we might look for as the result of such a reduction of dead weight would vastly increase the momentum of the charge, and the saving of muscular power which is now expended in bearing it through a long campaign, and the immunity from sore backs, will be found even more valuable than this.

We now pass on to the changes we would propose should be adopted for Light Cavalry, or rather to consider how such a force may be produced in a state of efficiency, fully equal to compete with any light troops armed with rifles, which may be brought against it.

In the first place then, the Light Cavalry, *par excellence,* should be brought to regard their horses chiefly as means of rapid locomotion, not as fighting animals. The men should be light, energetic, quick-sighted, and, above all, good marksmen. They should be armed with the best breech-loading rifle, with sling, and sword bayonet, and they should ride active, wiry ponies, trained to stand rooted to the spot when the riders dismount.

There are plenty of shooting-ponies in South Africa which answer to this description; they can gallop safely with loose rein over any ground, and will pull up short, and stand without moving a muscle at a touch of the reins, while their rider takes his shot from their backs, or dismounts if he has time to do so. These ponies require but little forage beyond what they can pick up for themselves, when they are off-saddled and knee-haltered.

They are seldom shod, never kick, and when knee-haltered may be safely trusted not to wander many yards. This means of securing horses is very simple and convenient, consisting in attaching the head-collar to the fore-arm, a little above the knee of the animal, by a rein or collar rein of untanned leather.

The Light Cavalry ought to be organized upon the same principle as the Irregular Cavalry of India, and the Frontier Mounted Police of British Kaffraria, viz. by paying each man a daily rate of pay, which shall enable him to keep himself and his horse, and this species of Cavalry can be maintained by such means on far cheaper terms than our present Light Cavalry, as has been proved wherever the plan has been tried.

The man should be compelled on enlistment to bring with him an animal in every way up to the mark, and from that time forward to keep him in a fit state for any service, on the condition that the Government shall pay him a fixed rate of compensation for any loss of the horse caused by the requirements of the service.

The advantage of having men of a certain position, who have an interest in their horses and arms given by the possession of actual property, would be great, and the control of their officers over such men, provided the former are carefully selected, and entrusted with full powers to stop pay and discharge men at pleasure, must be very great, and easily exerted; while the simplification of accounts and money matters, when all commissariat and clothing arrangements are left to individual care of the

men, will give greater leisure to the officers, and enable them to devote all their energies to more important duties.

The Frontier Mounted Police of British Kaffraria are paid at the rate of 4*s.* 3*d.*, to 4*s.* 6*d.*, per diem, out of which they provide every necessary for themselves and their horses, and on these terms the cost of each man, including pay of officers, &c., amounts to about £87 per annum.

The force of Light Cavalry with an army, if confined to its distinctive duties, need never be very strong, and as it will always be employed on the outposts, and in advance of the army, it could safely be abandoned to its own resourses without danger of starving itself, or of materially interfering with the commissariat arrangements necessary for the support of the rest of the army, which is compelled to move in masses.

Every third or fourth man might bring into the field a second pony, in all respects like the one he rides, but carrying a pack-saddle, to be loaded with what little food and clothing may be required for his squad. This second animal would be his own property, and he would receive additional pay for its sustenance, so long as it may remain fit for work. The squads should be encouraged to consider their interests bound up with this beast of burden, and to be as accommodating as possible to one another; but, if disputes should arise, each man must be limited to a small fixed weight, and not be allowed to place any more than this, on the pack-horse, or to carry anything on his own riding-horse.

The habits of independent action and foresight which such a system would generate in the force employed on the outposts must prove invaluable to the Army, which depends upon its outposts for warning of the approach of the enemy, and for that knowledge of his force and movements, which should govern every order which it receives.

Having thus sketched out the changes we deem indispensable to restore to Cavalry the high relative position with regard to the other arms, of which the general introduction of arms of precision has temporarily deprived it, we would, for the sake of clearness, briefly recapitulate them before closing this paper.

1st. Reconstruct the whole mounted branch of the Line under two distinct classes of Heavy and Light Cavalry, or, more properly speaking, of Cavalry and outpost troops.

The changes recommended for the first class are:

1st. Simplicity of drill, by discarding rear ranks and introducing the formation of "fours," &c.

2nd. Reduction in weight carried by the horses, to be brought about by altering the terms of enlistment, abolishing carbines, valises, and every unnecessary part of the horse appointments, &c., &c.

For the second class, or outpost troops:

1st. Special organisation for these duties, which are to be performed chiefly on foot, the horses being only intended to give facilities of rapid locomotion, and to bring the men fresh and cool to the decisive point.

2nd Selection of the men as light, active, good marksmen: and—

3rd. Simplification of interior economy and commissariat to give the utmost mobility to this force.

RIFLE TRAJECTORIES AND RIFLES.*

By Arthur Walker, Esq., 79th Highlanders, Lieutenant Instructor, School of Musketry, Fleetwood.

Until the last few years the small-arms practice, so called, of the British army has been a farce; it is notorious that not one man in a thousand of Wellington's troops had ever learnt to shoot, and it was held that of every 250 bullets fired, 249 were thrown away.

The modern improvement in small arms has however changed all this: the Rifleman of 1862, dealing death at a distance of 1,000 yards, is a very different being from the soldier of 1800, with his musket killing once out of 250 times at a distance of 100 yards, and the improved weapon of our day has, at a minimum calculation, rendered the fire of infantry soldiers fourfold more effective than it formerly was; *always provided*, however, that the training of the soldier in whose hands this weapon is placed, has been such as will enable him to elicit or develope its full power; for, whatever the range and accuracy of a rifle may be, it obviously loses very much of its value and scope if placed in the hands of a man unskilled in its use. For, just as highly improved machinery involves increased intelligence on the part of the mechanic and engineer, and as the introduction of steam-ploughs and reaping-machines in farming necessitates a superior description of agricultural labourer, so in like manner the introduction of the rifle into our service demands on the part of the soldier a certain knowledge, which can only be imparted to him by means of a special training; to place the rifle of the present day in the hands of the "pipe-clayed automaton" of former days, would be an anachronism and inconsistency.

In this course of musketry training, there is perhaps no portion of it more absolutely essential to men armed with the Enfield rifle than "judging distance." For the most part we are too apt to rest satisfied with becoming tolerably good shots, at targets placed opposite us, at fixed and known distances, forgetful that in the field of active service—which after all is the only proper medium through which to regard the efficiency or non-efficiency of the rifleman or soldier—unless he can at least judge the distance at which the enemy is from him with a certain proximate accuracy, and adjust his sight accordingly, he might almost as well for all practical purposes be armed with the smooth-bore gun of a century back. A striking illustration of this is given by a writer in Blackwood's Magazine, in his description of the equipment of the Garibaldians, immediately prior

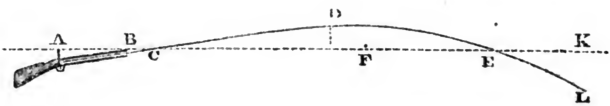
* Communicated 31 May, 1862.—Ed.

to the battle of Melazzo, in Sicily. He there states: "For the most part the force was armed with 'Enfields,' but few knew how to develope the use of that deadly weapon, the sights being deemed a superfluity." The question naturally suggests itself to the reader, Why were the sights thus deemed superfluous? and the obvious answer arises, that it was mainly, if not entirely, owing to those men, thus armed, being utterly ignorant of and deficient in the power of judging distances.

We witness now every year at Wimbledon a magnificent spectacle of rifle-shooting; but take some of those crack Wimbledon shots, and place them in an open country, in an Indian jungle, or a Chinese rice-field, and, without telling the distance, ask them to hit an object the size of a man, some considerable way off, and they will at once frankly admit their inability to do so. Judging distance is ignored at Wimbledon, and perhaps for divers reasons necessarily so; but so long as we have a rifle furnished with a back sight requiring adjustment, or retain any pretension to be practical soldiers, we cannot ignore its absolute necessity.

The question as to whether a soldier can be trained to judge distances or not, has long since been affirmatively determined, and the accumulated returns at the Hythe School of Musketry establish beyond all doubt that the majority of soldiers, provided they have average eyesight and an ordinary amount of intelligence, may acquire a proficiency in judging distance sufficient for all practical purposes.

Having thus indicated the requirement existing for every one armed with the Enfield Rifle being able to judge distance with a certain degree of approximate accuracy, I shall now endeavour to show why it is this necessity exists, and I shall also essay an explanation of the general principle upon which the present system of teaching judging distance is based.



In the above figure, let the line C D E L represent the trajectory of a bullet, and let the line A K illustrate the line of sight. If we consider the relative position of the trajectory here towards the line of sight, it will be observed that for a short distance beyond the muzzle of the supposed gun the trajectory is below the line of sight, it then cuts it at the point C, and I may remark that this point of intersection is of no value in the consideration of the firing of arms; beyond the point C, the trajectory gradually rises till it culminates at D, and here I may parenthetically remark the point of culmination in the Enfield trajectory, where it obtains its meridian height, is a very little more than mid-way at short ranges, and nearly two-thirds of the entire distance at the longer ranges.

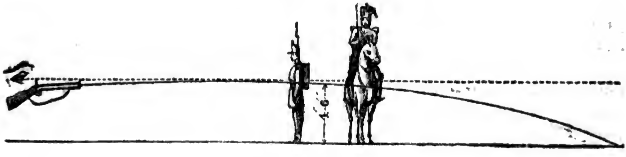
After culminating, the trajectory makes a gradual descent till it again cuts the "line of sight" at the point E, this point of second intersection of the trajectory with the line of sight is of important interest.

Abroad, this constitutes what is termed the "point blank;" the English acceptation of this term is, however, entirely different. Point blank, according to our interpretation, consists in the first graze made by a bullet fired from any piece the axis of which has been laid parallel with the horizon; as the flight of a projectile can, however, be fully explained without making use of a term so ambiguous and liable to be misconstrued, I shall dispense with further allusion to it. It will be sufficient, at present to direct your observation to the fact that to hit a small object, an apple or oyster-shell, that apple or oyster-shell must be placed in the direction of our line of sight exactly where the trajectory, which it must be borne in mind always indicates the actual course of the bullet, makes its second intersection with the line of sight; for by inspecting the foregoing figure it will be seen that if we wish to strike an object F between the point E and the muzzle of the gun and aim directly at it, the ball will pass above it a certain distance F D and it will be the same for all points between C and E: and, again, if we wish to strike an object K beyond the second point of intersection and aim directly at it, the ball would pass below it a certain quantity, H K, and so for all points beyond E. Hence it appears that, in order to hit an object, it is necessary that it should be precisely at the point of second intersection of the trajectory with the line of sight.

But fortunately for us as practical soldiers the objects we are taught to aim at and hit possess a considerable degree of height, thus the average height of an infantry soldier is assumed to be six feet, and that of a cavalry soldier on horse-back eight feet six inches, hence it follows that not only should we hit these objects when at the point E, but equally so within certain limited distances on either side of that point.

Let us give this a definite application. If the Enfield rifle is taken, and the sighting or elevation for 100 yards made use of, matters are so arranged, that if aim be correctly taken, the bullet would pass through the centre of a man's body at 100 yards distance; but as the the bullet, when fired with this elevation, never attains a greater height than 4 feet 6 inches, where in fact it culminates—and as it does not make its first graze or strike the ground till 195 yards from the firing point—it follows that not only will the bullet hit a soldier in the waist-belt when standing a hundred yards off, but it would hit him equally somewhere higher, even were he to advance to the muzzle of the piece, and on the other hand, even were he to get 195 yards off, he would there be hit in the feet.

100 Yards.



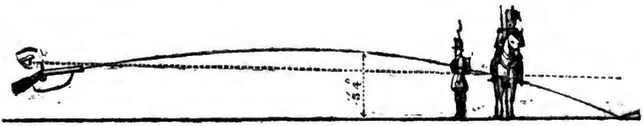
100

Thus appears that practically no one could stand in the direction

the line of sight for a distance of 195 yards with impunity, and this distance constitutes what is technically termed the "dangerous space" (for an elevation of 100 yards.)

With the elevation due for 200 yards, the bullet culminates at a height of 5 feet 4 inches from the ground, and makes its first graze at a distance of 280 yards from the muzzle, so that we here again have Infantry under the power of our rifle throughout the entire flight of the bullet.

200 Yards.



Moreover it is worthy of remark, that, as the bullet rebounds or ricochets at very nearly the same angle as that with which it strikes the ground, the angle of incidence and reflection being equal; and as at this and other short ranges, that angle is comparatively low and flat, so to speak, it follows that we may with a certain degree of prudence, having due regard to the nature of the ground, calculate on an effective ricochet-fire of at least some 20 or 30 yards further, so that practically it may be averred, that if the sight is adjusted to 200 yards, and the rifle be held straight, some part of a man must be hit throughout a distance of 300 yards, irrespective of any further power of judging distance than is required to tell the difference between 1 yard and 300—a useful fact this to be borne in mind by a sentry on outlying picket, if taken by surprise.

So much for the trajectory in reference to Infantry soldiers at those two ranges; small reflection is required to perceive that Cavalry would fare no better, but rather a degree worse, inasmuch as they would be equally under the influence of our bullet throughout its flight, while at the same time their greater height affords a larger target for aiming at, and the disadvantage of this greater height makes itself even more apparent to us, in reference to the trajectory, at the next and following distance of 300 yards.

With the elevation for 300 yards, the culminating height of the bullet is 7 feet, and its first graze 370 yards from the firing point, giving as a dangerous space for the Cavalry soldier on horseback, with an average height of 8 feet 6 inches, 370 yards; and, considering the nature of the ground over which Cavalry must of necessity act, and their greater height, it certainly would not be too much to assume that we may depend on the effect of ricochet fire for some 30 yards beyond the first graze; hence we arrive at the important conclusion that, admitting you are no judge of distances, all that an Infantry soldier need do if attacked by Cavalry is, to adjust his sight to 300 yards, and calmly wait till his mounted enemy come within the to him fatal distance of 400 yards, in order to make him bite the dust, for such is the lowness of our trajectory here, that you cannot miss him.

Never did knowledge more clearly constitute power than this; and had the 93rd Highlanders, or rather those who commanded them, but known this little fact on the morning of the 24th October, 1854, we might have been spared the disastrous sequel of the Light Cavalry charge.

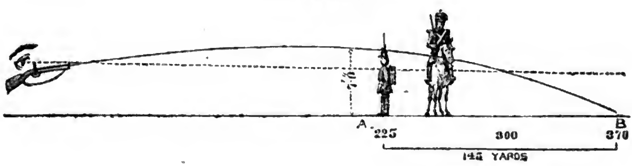
As a proof that I am not at all exaggerating the effect of ricochet fire at those distances, I may adduce the melancholy instance of the death of Captain Collins of the 26th regiment, from the ricochet of a bullet fired at the Curragh of Kildare. "A party of soldiers were firing volleys at the usual distance of 400 yards, when, as Captain Collins was crossing the range in rear of the target-butt, at a distance of some 1,100 yards from the firing party, a bullet, doubtless fired with more than the necessary elevation, passed over the butt, making its first graze at about 900 yards from the firing point; it appears then to have made a ricochet of some 200 yards, striking Captain Collins in the heart and producing instant death." That the bullet had first ricocheted was proved by the fact of blades of grass being found imbedded in the lead.

Thus far it must be very satisfactory and consolatory to such as would seek a "royal road" to judging distance, to know that we are not absolutely dependent upon every soldier knowing the exact distance of an object, for from the height of the trajectory and its comparative flatness at the ranges to which I have just referred, we are, to a certain extent, rendered independent of judging distance.

We now arrive, however, at a point where the necessity of being able to judge distance with a greater degree of accuracy becomes clearly palpable, for as our bullet attains a culminating height of 7 feet when fired with the elevation due to 300 yards, it follows that during a portion of its flight it would manifestly pass harmlessly over the head of a soldier, *even* were he a giant 6·99 feet in height.

It has been determined by careful experiment, that the bullet would first catch an Infantry soldier in the hair of the head as it were, at 225 yards from the firing point; at 300 yards, provided aim had been properly taken, it would strike a man in the waist-belt; and at 370 yards it would strike him somewhere in the feet.

300 Yards.

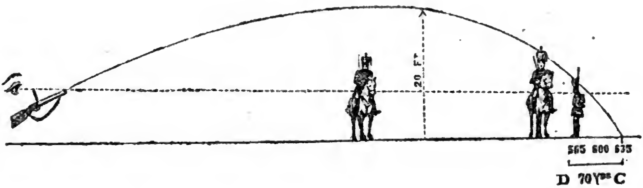


Our dangerous space, therefore, is now limited to the distance between A and B in the above figure, that is 145 yards.

With the view of showing that the necessity of judging distance increases with the range, let us proceed at once to trace the course of the trajectory at 600 yards. The bullet now reaches a height of 20 feet before culminating; it first catches an Infantry soldier in the crown of the head

at a distance of 565 yards, and strikes him in the heels (makes its first graze) at a distance of 635 yards.

600 Yards.



Our dangerous space is thus considerably curtailed, lying merely between D and C, equivalent to a distance of 70 yards. The practical inference to be deduced from this is, that to fire with accuracy the soldier should be capable of appreciating the distance of objects so as not to commit an error greater than A B in the first instance, and D C in the second, that being the respective margin permissible in either case for misappreciating the actual distance. In the case of Cavalry, in the latter instance, the margin, owing to their greater height, would be slightly more.

In teaching how to judge distances, the recruit is instructed first to take note of the size and appearance of men, placed opposite him, at fixed, known distances; he has as it were to draw a picture in his mind's eye, of these "fixed points;" to make, so to speak, a mental photograph of them, so that afterwards when he is called on to judge of men at unknown distances, by a process of inductive comparison, by looking mentally on that picture and on this, he arrives at a correct conclusion as to the number of intervening yards. At 100 yards, the lineaments of the face can no longer be discerned; the buttons seem to form a continuous line; the number or ornament on the cap is scarcely discernible from the band, but the different parts of the body: the movements of men individually, and the form and colour of the uniform, are perfectly distinguishable. At 200 yards, the buttons, as buttons, are invisible, and the face looks like a whitish ball under the cap, but the colour of the uniform, the badges of shakos, and cartouch boxes can still be distinguished. At 325 yards, the rifle at the shoulder and the different parts of the uniform are discernible: objects at this distance are said to have an apparent size of about one third their actual size. At 400 yards, objects have an apparent size of about a quarter their actual dimensions, the direction of the march of Infantry, and the movement of their muskets can be distinguished, and so on. The recruit is, at the same time, warned that all inductions of this character require modifications, dependent on his own eyesight, the position of the sun, the state of the atmosphere, and the background. A body of Infantry marching with the sun opposed to them, send out strong and constant rays of light, in the direction in which they are marching; when the sun is behind them, no light is shown. In foggy or cloudy weather, objects having less light falling on them appear more distant than they

are, whilst in clear sunshiny days, being much more lighted up, the details are more clearly visible, the object appearing nearer than it is in reality.—A man placed before any high building, high tree, &c., will appear smaller and more distant than he would appear under other circumstances, whilst on elevated ground, with the sky only visible beyond him, he will appear larger.

In judging distance practice, so called in contra-distinction to the drill, the soldier is taught to apply the knowledge previously acquired, under the head of drill, by giving a separate individual answer as to his estimation of the distance of men placed at an unknown number of yards from him; when, providing his answer is within the margin permissible, or, in other words, somewhere within the prescribed limits of the dangerous space, as already explained, he receives a number of points, in the register kept of the practice, to denote the relative value of his answer.

The foregoing explanation will afford a general clue to the principles upon which the present system of imparting judging distance in England is based—that system is admitted, I believe, to be the best extant, and is used, with but slight modification, throughout the entire continent of Europe, and the two Confederacies of America.

Enough also, I trust, has been said, without further multiplying figures, to show the advantage derivable from every soldier being acquainted with every detail connected with the trajectory of his bullet; the figures here alluded to should be familiar in the mouth of everyone armed with the Enfield, as household words; for, though it is true that instruments have been designed for the computation of distances, in the excitement of battle the soldier would not be capable of using such, and all instruments are thus far unsatisfactory either from giving an inexact approximation, being too complicated, or requiring too much time to use them.

After all, an approximation such as the practised eye can give is most to be desired, and there are few men indeed who cannot with a little labour and care attain such proficiency in judging distance as will at least enable them to strike an object the size of a battalion in column at a distance of 900 or 1000 yards.

Fired with the elevation necessary for 900 yards, the Enfield bullet actually acquires a height of about 50 feet before culminating, and hence the curvature of the latter part of its track is so great that in a measure it may be said to approach the vertical, and herein lies the difficulty of obtaining accurate shooting with the Enfield rifle at this and other long ranges; we have, as it were, not only to fire at but into an object, the bullet has to be dropped on a man's shako in order to hit him, so that the slightest possible error in the matter of elevation or taking aim is at once fatal; a finer sight than usual will cause the bullet to fall short of the mark, while a fuller sight will cause it to fall over and beyond. Moreover, we now lose the effect of ricochet-fire owing to the high angle at which the bullet strikes the ground.

Even according to the Hythe average at this distance, only 13 out of every 100 shots fired at a target 6 feet high and 12 feet wide, ever take effect. Increasing the width of the target aids us comparatively little, the difficulty is one of elevation, not direction. It is owing to this that none but highly trained soldiers, marksmen in every sense of the word, should ever

be allowed to fire at long distances (such as 700, 800, and 900 yards) at smaller objects than a column of men or troops, whose depth would make up in some degree for any misappreciation of distance, or effect of faulty aim.

To drop a ball from an Enfield rifle on to a reconnoitring staff-officer at 900 yards, could be done, probably, by only a few men in the regiment; but if a hostile battalion should endeavour to advance from 900 yards distance to 300 yards, every man in a regiment ought to contribute his quota towards their destruction, for there would be no need of nicely timing the discharge or of minute accuracy of elevation.

It therefore becomes apparent that the advantages to be derived from a low or flat trajectory cannot be over estimated; all our difficulty in shooting is owing to the bullet moving in a curved line, and if it were possible to have a rifle to project a bullet in a line, parallel, or nearly so, to the earth's surface, I need hardly say, judging distance would be no longer necessary, and schools of musketry become to a great extent superfluous. The Enfield rifle is surpassed in this respect by rifles which have emanated from private manufacturers, and by none more so than that of Mr. Whitworth, which, so far as reliable data can be taken, has the flattest trajectory known.

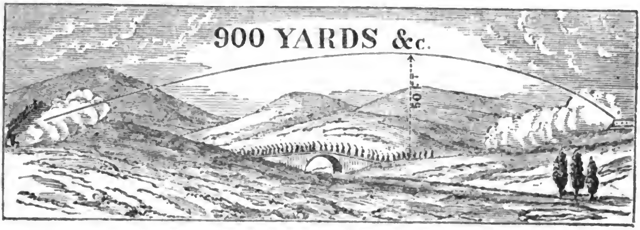
To put the comparative merits of these two weapons in the matter of trajectories in more familiar and definite terms, I may state, that, whereas the curve described by the Enfield bullet at 500 yards (fired at an angle of 1° 30′) attains a height of 15 feet at its highest part, the Whitworth at this range (at an angle of 1° 15′) only acquires a height of 8 feet 6 inches, in other words, the trajectory of the Whitworth, at this range, is more than 40 per cent. lower, and therefore better, than that of the Enfield, and the practical corollary which flows forth from this fact is, that if a body of cavalry were to charge riflemen (infantry) from a position 500 yards off, the Whitworth bullet aimed for that distance would hit them in any part of its flight, while the Enfield, at the centre of its curve, must whistle harmlessly over their heads, though a first-class marksman fired the shot.

Although the highly curved trajectory of the Enfield-rifle at long ranges must obviously be regarded as a decided fault and a weakness, so to speak, in its construction, yet certain exceptional circumstances may arise, under which this very fault may be turned to positive advantage.

In actual warfare it continually happens that troops advance to storm a breach or attack an enemy in position, covered by the fire of artillery. This was done, for example, with admirable result, at the seige of San Sebastian, in Spain, and again, in more recent times, with a like success, at the capturing of the Taku Forts the other day in China; in the former instance, howitzers were for the most part made use of; in the latter instance, Armstrong rifled field-guns, fired with a smaller charge and increased elevation. Now, let us put artillery on one side, and, assuming that it has been prevented coming "to the front," owing to the nature of the ground, want of horses, or some of the other hundred and one impedimental accidents liable to occurrence in the best regulated war, let us see, whether under such circumstances the Enfield might not, in a modified manner, be made to do the work of the big guns.

We will suppose that a small brigade of infantry consisting, say, of three regiments, with a respective effective strength of 600 men, armed with

Enfields, but unsupported by artillery, have to attack an open field-work which has been thrown up and occupied by the enemy.



The work rests on the crest of a hill, the natural slope of which serves as a glacis, girt at its base by a small stream spanned by a bridge, which, owing to the nature of the surrounding country, constitutes the only practicable approach; the attacking force advances in column across the opposite declivity (or plain) till within range of the enemy's artillery, when it deploys into line, and a further advance is made till within some 900 or 1000 yards of the enemy's work, and here, while one half of the force continues to move on to the assault, the other half commence firing volley after volley into the open area of this field-work, over the heads of their comrades, at the easy rate of two volleys per minute, thus 1,200 men would in ten minutes project no less than 24,000 Enfield bullets into the Redan, into a comparatively circumscribed area; beneath such a hailstorm of lead, it would be impossible for human life to exist, and the storming party would clamber over the parapet only to find guns deserted and gunners *hors de combat.*

Nor must it be supposed that the occurrence of an incident such as I have attempted to describe, is beyond the limits of probability or fact, on the contrary, it is authenticated that at least upon two occasions during the suppression of the Indian mutiny, a similar adaptation of the Enfield rifle was made under nearly parallel circumstances to those here related. But, even admitting that the chances of such a combination of circumstances recurring are few and far between, and leaving out of view the possibility of partially covering the advance of troops by means of Enfield rifle fire; what has been said will at least serve to show that the vertical fire of the Enfield at long ranges may be made use of with admirable effect for siege purposes, where a large area is presented for firing into, for enfilading a redoubt, or hindering a working party throwing up a field-work; nor must it be supposed that the range of the Enfield rifle for purposes of this kind is limited to 900 yards; it is capable, in reality, of being used effectively at much longer distances (the soldier, with that view, having merely to raise his eye as much above the back-sight as the distance appears to justify, still keeping the foresight aligned with the object). Instances are on record in this country of the Enfield having killed sheep 2000 yards off, and at New Zealand, during the present war, in the country of the Taranakis, one was fired with effect from a fixed rest with an elevation for 3000 yards.

After the fall of Sevastopol, amongst other things, Russian officers related that their men, when seated smoking in fancied security beneath their doorways, had frequently been struck down by Enfield bullets, at distances almost fabulous. Its deadly effect at vast distances made it the dread of the Sepoys, who termed it "the gun that kills without making any sound."

Notwithstanding, however, that so many things may be said in favour of the Enfield rifle, partiality must not be suffered to blind us to its defects.

The late Lord Herbert, when Secretary for War, claimed a "ten years' life" for the Enfield rifle; experience proves, however, that its longevity is even less than this, and practicians know full well that long ere that prescribed decade has run its course, the weapon, owing to an inherent susceptibility to the abrasion of the bullet, and the frictional action of the ramrod, especially towards the muzzle, where the grooves are shallowest and barrel weakest, ceases to be a rifle in all save name. Under such circumstances, the economy of continuing the manufacture of this description of rifle, and its retention as a service arm, may well be called in question. Any scruples of an economical kind, however, must give way to doubts of a graver character, when the *comparative* efficiency of the weapon is considered.

Without entering into detail, it may be stated that a careful investigation will satisfy any one that this particular arm, if it has not already become inferior to that of other nations, is at least greatly inferior to the rifles which have emanated from the private gun factories of this country—rifles which are made use of at every Volunteer rifle match, to the almost entire exclusion of the military arms.

In effect, the trajectory of the "Enfield" is, practically speaking, too high. At great distances the bullet plunges, and the "dangerous space" is reduced to a few yards, thus necessitating an elaborate system of judging distances.

It is true that a reduction in the height of the trajectory involves, almost as a necessity, a reduction in the bore of the rifle, and against this it is gravely argued, that the calibre of the Enfield could not be reduced without injuriously affecting its efficiency as a military arm, and that in order to kill a man the projectile must have a diameter of ·577 of an inch, and that the Whitworth bullet with a diameter of ·45 of an inch is too small for that purpose. This surely is "splitting hairs." One cannot but remember that the self-same argument was urged in days past against the introduction of the "Enfield;" and the Duke of Wellington, who was obstinately wedded to "Brown Bess," stickled to the last for its large bore, and the necessity of making a big hole in the enemy; so that, had he lived, our men would have had to fight at Inkerman with smooth-bores versus rifles.

The increased power of penetration surely more than neutralizes any hypothetical disadvantage arising from the reduction in the diameter of the projectile.

At Inkerman, an Enfield bullet was known to pass through three Russians; and, as at Hythe, in 1857 (*vide* Report), it was demonstrated that the relative penetration of the Enfield and Whitworth projectiles was as 4 to 11, it follows, as a consequence, by the simple application of the rule of three, that at Inkerman, where, as every one knows, the Russians were in close

order, one Whitworth bullet would have killed eight Russians, slightly wounding the ninth!

Another argument usually brought forward against the gradual adoption of a rifle with a smaller bore than that of the Enfield is, that it would necessitate our having two sizes of ammunition in the service; but this objection cannot surely be seriously entertained, inasmuch as the evil, if such it can be called, would be merely of a temporary character: moreover, the exception loses much of its force from the fact of our artillery having many different sizes of ammunition in use at one time.

In conclusion, I cannot but express regret, before quitting this subject, that the Volunteers, who were expected by the regular service to originate so much of a progressive character as to weapons of war, should have contented themselves with the common arm of the private soldier, instead of making a strenuous effort to obtain a small-bore breech-loader, with the trajectory so low and flat that the necessity of judging distance would have been rendered unnecessary, and the close advance of cavalry made impossible.

That in course of time the bore of the Enfield will be further reduced, and that the present system of muzzle-loading will eventually give way to that of breech-loading, is beyond a doubt, and for the sake of the British soldier let us hope that this good time coming, is not far distant.

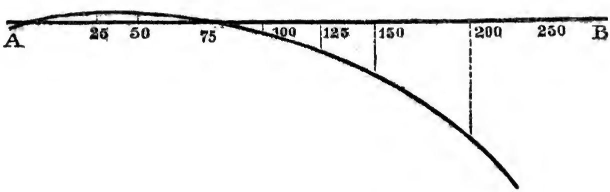
An eminent statesman recently remarked, that the spirit of progress of the nineteenth century generally ends in a recurrence to ancient ideas, progress in knowledge and civilization reproduces the contrivances of an age which we style barbarous; the great points sought for in the military rifle of our day are celerity and accuracy—that it should be *celer et certus* —be capable of a quick discharge, and up to a reasonable distance possess unerring accuracy. These are the very qualities our worthy forefathers claimed for their long bows 600 years ago; the Old English long bow had a range of 600 yards, and it could shoot 12 times in a minute: we want nothing more in a good breech-loader.

So true it is that "there is nothing new under the sun"—in this very paper, many of my ideas have been gathered from the remarks of others, who have gone before, or are yet alive; but, while making this general and grateful acknowledgment to them, I trust it will not render the substance of these remarks less acceptable at the present time.

APPENDIX.

Method of determining practically the Construction of the Trajectory of a Musket or Rifle.

Strictly speaking, in order to trace the trajectory, it would be necessary to find the mean vertical deviation of a given number of shots for all points between the muzzle of the rifle and the limit at which it is wished to trace the mean curve; for it is obvious, that if we can obtain the vertical drop as it were of the mean point of impact of a given number of shots, fired without changing the charge, direction, or elevation, at all points of our range, the curve can then easily be drawn by simply uniting such points in a continuous line. But to save the time and trouble necessary for such a labour, it is sufficient for all practical purposes if we limit ourselves to finding the mean vertical deviation of a given number of shots, fired under the conditions already specified, corresponding to the principal distances likely to be used in practice, such as 25 yards, 50 yards, 75 yards, 100 yards, 200 yards, 300 yards, &c., and then use them in the following manner:



Upon the indefinite right line A, B, representing the line of sight, take lengths proportional to the distances, 25 yards, 50 yards, &c. &c., and through each point, thus found, draw a perpendicular, upon which measure the vertical distance found for the point of mean impact corre-

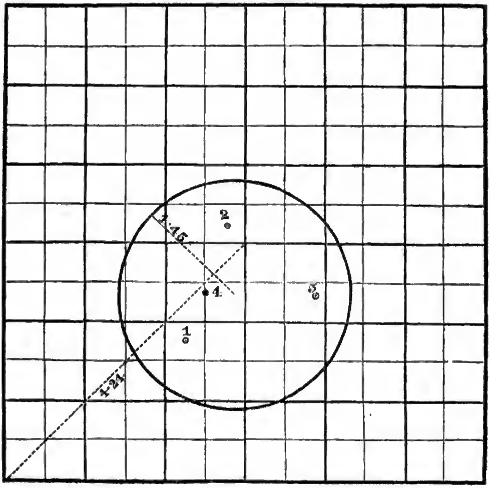
sponding to this distance. Join all the points thus found by a curve continuous and regular; this curve is the same nearly as if we had obtained all the points of mean impact and joined them, or, in other words, it is the mean trajectory of the arm. "This method, simple and expeditious, presents sometimes irregularities; when, for instance, owing to the difference of height of the points of mean impact, the curve presents inflexions that reason and common sense refuse to admit. In this case, rectify in the following manner: by taking into consideration the general form of the curve, and trace it in such manner as to leave as many points above as below, and give it a mean direction between all the points. This is done by increasing the less and diminishing the greater heights in a convenient manner. In every case, before making the rectification, seek to ascertain the causes of these irregularities, and endeavour to remedy them if possible by new experiments. Such is the method to be followed to determine, with anything like accuracy, the trajectory of an arm. It was in this manner that the French determined the trajectory of their musket, firing with a charge of 138 grains, and ball 0·62 of an inch. The precautions taken for this important operation, the skill of the marksmen that fired, the care with which they verified by calculation, and corrected by the drawing of the data obtained, all induce the belief that the utmost confidence may be given to the result of their labours, and that the trajectory thus determined was as nearly correct as it is possible for it to be."

Method for ascertaining the Mean Deviation.

A mark must be fixed upon to aim at, so that the whole of the shots may strike the target, and aim is always to be taken at the same point. A diagram must be kept on which each shot should be placed according to its position upon the target; each shot to be measured horizontally from left of target, and these horizontal measurements to be totalled and divided by number of hits, thereby obtaining the mean horizontal measurement. The mean vertical measurement is obtained by measuring vertically from the bottom of target; the total divided by number of hits gives the mean vertical measurement; the intersection of these two measurements on the diagram will determine the point of mean impact; the absolute deviation of each shot from the point of mean impact will then be found by measurement and applied to the scale; and the mean and absolute deviation, by adding the absolute deviation of every shot (including the absolute deviation allowed for misses), and dividing the sum by the total number of shots fired. A circle, described on the diagram from the point of mean impact, as a centre, with the mean absolute deviation as a radius, will show at a glance the merit of each arm, &c. &c. The distance of the point of mean impact from the mark aimed at is calculated in the same manner as for the absolute deviation of each shot, and denotes the error due to wind and defective sighting.

The allowance for misses might be half the diagonal of the target, which is the measurement from the centre of target to any of its four corners.

Diagram showing the mean absolute Deviation of 5 Shots.



6 feet square.

No. of Shots.	Measurement.		Deviation.		Absolute Deviation.	Remarks.
	H.	V.	H.	V.		
1.	2·27	1·76	·58	·64	0·87	
2.	2·76	3·20	·09	·80	0·84	
3.	„	„	„	„	4·24	Miss.
4.	2·52	2·35	·33	·05	0·31	
5.	3·87	2·30	1·02	·10	1·00	
Total . . .	11·42	9·61	2·02	1·59	7·26	
Mean . . .	2·85	2·40	„	„	1·45	

The Siege of San Sebastian, page 443.

The incident here referred to is thus chronicled by Sir William Napier the brilliant historiographer of the Peninsular War:—"Graham, standing on the nearest of the Chafre batteries, beheld this frightful destruction with a stern resolution to win at any cost; and he was a man to have put himself at the head of the last company and died sword in hand rather than sustain a second defeat. But neither his confidence nor his resources were yet exhausted. He directed a new attack on the horn-work; and, concentrating the fire of fifty heavy pieces upon the high curtain, *sent his shot over the heads of the troops gathered at the foot of the breach;* a fearful stream of missiles, which, pouring along the upper surface of the curtain, broke down the traverses, shattering all things, and strewing the rampart with the mangled limbs of the defenders. When this flight of bullets first swept over the heads of the soldiers, a cry arose from some inexperienced people 'to retire, because the batteries were firing on the stormers;' but the veterans of the light division being at that point were not to be so disturbed, and, *in the very heat and fury of the cannonade,* effected a solid lodgement in some house ruins actually within the rampart on the right of the great breach."

Report referred to in page 445, *and extracted from* "THE TIMES" *newspaper, dated 23rd April,* 1857 :—

"For the last few days a very interesting and important series of experiments has been in progress at the Government School of Musketry, Hythe, in order to test the comparative merits of these two rifles. The trial, which was of the most searching and impartial character, was conducted by Colonel Hay, the able head of the school, and has terminated in establishing beyond all doubt the great and decided superiority of Mr. Whitworth's invention. The Enfield rifle, which was considered so much better than any other as to justify the formation of a vast Government establishment for its special manufacture, has been completely beaten. In accuracy of fire, in penetration, and in range, its rival excels it to a degree which hardly leaves room for comparison.

"The following table gives the best results that have been obtained from ten shots of each arm respectively in the course of the experiments, which have extended over a week in time, and were brought to a close yesterday, in the presence of Lord Panmure, and of a number of military and scientific spectators :—

RIFLE.	Range in Yards.	Elevation.	Figure of Merit.
		Deg.	Feet.
Whitworth . . .	500	1·15	0·37
Enfield	500	1·32	2·24
Whitworth . . .	800	2·22	1· 0
Enfield	800	2·45	4·11
Whitworth . . .	1,100	3·45	2·41
Enfield	1,100	4·12	8·04
Whitworth . . .	1,400	5·	4·62
Enfield	1,400	6·20 to 7·	No hits.
Whitworth . . .	1,800	6·40	11·62
Enfield	1,800	—	—

"It would appear from these figures that at 500 yards, in 10 shots, the Manchester rifle has a superior accuracy of 1·87 of a foot; at 800 yards, 3·11; at 1,100 yards, 5·63; and at 1,400 yards and upwards the Enfield weapon ceases to afford any data for a comparison. In penetration, the results obtained have been equally decisive; the Whitworth projectile with the regulation charge of powder going through 33 half-inch planks of elm, and being brought up by a solid oak bulk beyond, while the Enfield ball could not get past the 13th plank.

"The shooting on Tuesday was more to satisfy Lord Panmure and the other strangers present upon the comparative merits of the two weapons than to show the limit of what each could do under favourable circumstances. Still the targets of every ten shots on either side bore decisive evidence of the superiority of the new rifle, as a glance at the following table will prove :—

Rifle.	Range.	Elevation.	Figure of Merit.
		Deg.	Feet.
Whitworth . . .	800	2·22	1·41
Enfield		2·45	5·67
Whitworth . . .	500	—	1·27
Enfield			3·30
Whitworth . . .	500	—	1·33
Enfield			4·01

"The last entry in the table records the mean radial distance from a central point of 10 shots fired from a table-rest by Colonel Hay and Mr. Guner, the manager of the Enfield factory. Both are first-rate marksmen, yet at 500 yards the Manchester rifle in the hands of the former gives three times as good shooting as the latter can get out of the Government arm. All the other trials were made by firing from a beautifully-constructed machine rest, which placed both weapons on a footing of perfect equality as to the conditions under which they were tested. In addition to the foregoing experiments, there was one for showing that with cylindro-conoidal balls, on the expansion principle of those used for the Enfield rifle, very superior shooting could be obtained from Whitworth's hexagonal bore. This was most satisfactorily established, the mean deviation on the target from the centre of the group of 10 hits being only ·85 of a foot at 500 yards range. It will be observed that at 500 yards range, at which the practice commenced, the shooting of Whitworth's rifle was so much better than the other that no great distance was attempted. A reference to the first table of experiments will also demonstrate that the target made by the former weapon at 1,100 yards is nearly as good as that made by the latter at 500. These are great results to have achieved, and amply justify the forethought of the late Lord Hardinge in securing the services of so eminent a mechanic as Mr. Whitworth for the improvement of the rifle. Until he took the subject in hand, the proper principles for guidance in the construction of the weapon had not been accurately determined. The manufacture was still conducted by rule of thumb, and in a very

hap-hazard way, on the most important points. The use of grooves and an expansive projectile made it impossible to secure the requisite amount of pitch in the rifling, and the indispensable hardness of metal in the bullet for *penetration*. Moreover, from the small amount of bearing the wear and tear both in the barrel and in the projectile were enormous, and the length of the latter could not be increased without causing it to capsize in its flight. By the polygonal bore and rapid pitch, to which the form of the bullet accurately conforms, Mr. Whitworth has rendered stripping impossible, and his rifle when fired, acting exactly like a male and female screw, the projectile must rotate with perfect steadiness and precision on its axis. He can increase its length so considerably as to secure space for converting it into a shell if necessary, and, being able to use metal of any degree of hardness, he can adapt its form and strength exactly to the work which it has to perform. Thus with a rifle 39 inches long and half-inch bore, having a twist in 20 inches or two turns in its length, he finds no difficulty in penetrating a wrought-iron plate six-tenths of an inch thick, and some idea may be formed of the extraordinary power of his arm when we mention that his projectiles in their flight rotate at the rate of 15,000 revolutions per minute. The question of driving holes in the 4-inch breast-plates of floating batteries is at once solved by the application of these principles to artillery, the construction of which this new rifle proves must be completely revolutionized. A weapon which in expert hands will make good practice at 1,400 yards, and the range of which can be very easily helped by a telescope, if necessary, gives the *coup de grace* to our present system of field batteries. At the Alma it would have silenced the Russian guns or driven them from their position, rendering the rush of the light division, with the heavy loss of life consequent thereon, unnecessary. Nor during the siege of Sebastopol would the rope mantlets of the Redan and the Malakoff have given much protection to the men working behind the embrasures," &c. &c. &c.

Five years have elapsed since this was written.

SPLINT FOR COMPOUND FRACTURES.*

By S. Stacy Skipton, M.D., Assistant Surgeon, 78th Highlanders.

I am anxious to bring to the notice of the Members of the Royal United Service Institution, by means of this paper, a design of an apparatus or splint for "compound" fractures of the limbs; *i.e.*, those fractures accompanied with a wound which exposes the fractured bone to the air, such as are caused by gunshot, or other missiles of war.

In the surgical treatment of these injuries, in themselves always serious to the safety of the limb, if not actually dangerous to life, the great object is to apply a splint to support the broken bones in their proper position, at the same time that the wound or wounds in the limb may be left exposed for the application of the requisite dressings.

In the military service, and especially with an army in the field, it cannot be expected that the officers of the medical department can have access to the same resources that are available to the surgeons of a civil hospital, who are surrounded by all the materials which a liberal management permit them to make use of, modify and cut up, if need be, in order to meet the requirements of any one particular case under their care, and so render these materials useless for future casualties unless they present precisely the same conditions as the former one. With medical officers in the Army, on the contrary, economy in the amount of supplies of surgical apparatus is a primary consideration, and especially so under those circumstances in which they are likely to be most required, with an army in the field in the presence of the enemy; and *with us*, of course taking into consideration that this "field" is in a foreign country, and, may be, at a long distance from our base of supplies.

In the hospitals at Scutari and in the Crimea, in 1854-55, when the wounded arrived from the battle-fields of the Alma, Balaklava, and Inkermann, and from the trenches before Sebastopol, it was distressing to see them lying with fractures of the limbs from gun-shot injuries, for which no apparatus could be extemporised to meet the requirements of the vast majority of these cases. The medical officers were therefore compelled to use the ordinary splints from the stores, and, unfortunately, from the site of the wound being in the course of the splint, and requiring washing and dressing every day, the poor sufferer, officer or private, was daily put to the severe pain consequent upon the splint being removed, the wound cleansed and dressed, *without any adequate support to the injured limb*, and then the splint itself, which should have rendered this needful support to the broken bones, re-applied. Only those who have themselves suffered from a broken limb, and know what is the pain of having "the bones set," can form an idea of the suffering entailed upon our wounded; and, when we consider the constant state of fever which was maintained by this frequent but unavoidable meddling with the broken bone, it is not to be wondered at that so many of these severe injuries terminated unfavourably, necessitating, at the least, the sacrifice of the limb.

As, then, the requirements of the military service deny to a surgeon in

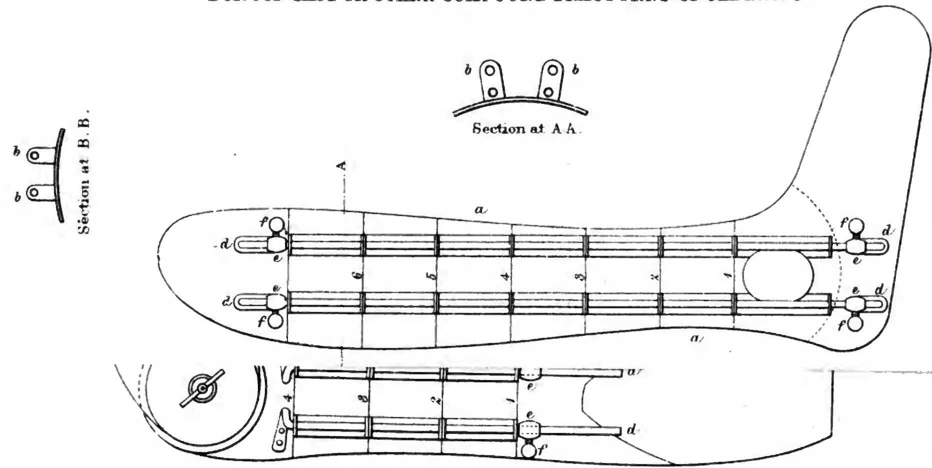
* Communicated 21st June, 1862.—Ed.

the field the great advantages possessed by a civilian surgeon, and render it necessary for the former to regard, while consistent with their complete efficiency, the portability, simplicity, and durability of his surgical apparatus, with economy also in the numbers and sizes of the splints he carries in his hospital stores, an apparatus or splint so designed as to meet all these requirements struck me as being, not only desirable, but exceedingly necessary; and such, I trust, will that be found a description of which I have now the gratification of submitting. The shape of the splints for the various limbs remains the same as those in common use, and the material best fitted for rough usage on a campaign, and which is by far the most cleanly of all, is the thin sheet-iron lacquered over, such as the ordinary splints have heretofore been made of. My object being to provide a splint, the surface of which might be capable of being interrupted at any part of its length, where, when applied to the limb, it might cover the site of a wound, I have taken any one of the common splints, cut it across into transverse strips, each of a width sufficient when removed to uncover a space the size of a gunshot wound, and at the back of these transverse strips placed vertical plates having holes pierced therein for a longitudinal bar, running along the back of the splint, to pass through; the terminal pieces of the splint are fixed to these longitudinal bars by rivets or screws at either end.

The accompanying drawings of the various splints, depicting a side-plan view of a splint for the arm and fore-arm, leg and thigh, respectively, show each to be composed of transverse strips (see Plate, *a*, *a*,) which, placed side by side, form the shape of the required splint; upon each of these are placed vertical plates *b*, *b*, (shown in a front view at the sections at A, A, B, B, C, C,) which have a hole pierced therein for a longitudinal bar, *d*,*d*, to pass through: each terminal piece of the splint is supplied with pillars *e*, *e*, and set screws *f*, *f*, or rivets to keep these pieces in their respective positions and required distances on the bars. Each transverse strip being numbered consecutively, no mistake need occur by their becoming misplaced, and thereby disarranging the shape of the splint. By loosening the screws and withdrawing the terminal piece from the bars, any one or more of the transverse pieces covering the site of a wound may be removed and set aside, and the terminal piece and the others replaced in their former position The splint thus applied, and bound on the limb with straps passing under the bars, presents an interruption in its surface, and, by leaving the wound uncovered, gives facility for cleansing and dressing it, without disturbing the support of the splint on the limb. The distance between the bars and the surface of the splint, or rather of the limb to which it is applied, renders any manipulation to the wound practicable and easy, and at the same time the patient is saved the agony and suffering, and consequent irritative fever, caused by having to remove and re-apply the splint to the broken limb after dressing the wound. Another advantage attendant upon this apparatus is, that the "pads" or cushions between the splint and the limb, and the bandages or straps which secure it to the limb, are more easily retained in a cleanly state; a desideratum to be appreciated chiefly by those who have served and suffered these injuries in a hot climate, such as that in which our campaigns have hitherto been carried on.

To face Page 454.

DR. SKIPTON'S PATENT INTERRUPTED SPLINTS
FOR GUN SHOT OR OTHER COMPOUND FRACTURES OF THE LIMBS.



I have described the principal advantages which this apparatus possesses above the common splint heretofore in use; but there is one other yet to be mentioned, and which, with the above, it exclusively presents; and one especially to be appreciated by our medical officers, whose resources as regards the numbers of the various sizes of splints must be considerably limited, whether at home or abroad. This consists in the same splint, which, at the full length of the longitudinal bars, would be sufficiently long for a tall man, being capable of reduction in length by removing one or more of the transverse strips, and bringing down the terminal pieces along the bars, and so making the splint short enough for a drummer-boy; thus relieving another great necessity of the service, economy in the *numbers* of the splints supplied to a force, and ensuring more comfort to the patient than he would have experienced from such apparatus as we had for use at Scutari in 1854, and later, during the Indian Mutiny, where, in many instances, owing to the enormous number of wounded suddenly taken under treatment, the splints were, in addition to their great disadvantages above referred to, either too short or too long for some particular case.

While the above would appear to be sufficient to recommend its adoption in those instances in which there is a wound co-existent with the fracture, this splint may also be used in cases in which there is no wound, in which the fracture is styled "simple." In these, the transverse strips would be left on the bars, no interruption of the surface of the splint being required; and the only objection to be raised against them—viz., their slight extra weight, which the additional quantity of the material in the bars, &c., renders unavoidable—is discarded as immaterial, when we consider that the patient is lying in bed, and required to keep his limb perfectly still, especially if the fracture be "compound." If the arm or fore-arm be the limb affected, and the patient be so far convalescent as to be allowed to be up, this extra weight is then supported in a sling from the neck.

Hitherto I have only spoken of this "*Interrupted*" splint as being advantageous to military medical officers, but the same reasons that would promote its adoption in the army medical department, where it has already established itself, would also render it requisite in civil life, to surgeons in charge of the various unions, and to those in country practice, who are bound to as strict an economical use of the materials and appliances at their command as possible, and who will not fail to see that the expense of these splints once incurred, will relieve them of the annoyance and trouble attending "make-shift" appliances, and always render them capable of attending at once and satisfactorily to any case of the serious nature above referred to, which may come suddenly under their care.

As medical officers form but a small minority of the members of the Royal United Service Institution, in writing the above, I have enlarged more freely on the strictly professional branch of the subject than I would otherwise have done; but I trust I may be excused for this, and hope that the public importance of the subject may be considered as a sufficient warrant.

***** I should mention in conclusion, that the manufacturers of this apparatus are Messrs. Whicker and Blaise (late Savigny & Co.), No. 67, St. James's Street, Pall Mall, S.W., who supply the army medical department with surgical instruments.—S. S. S.**

The Journal

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LECTURES.

Friday, March 14th, 1862.

COLONEL SIR GEORGE EVEREST, C.B., F.R.S., in the Chair.

GEODESY;* ESPECIALLY RELATING TO THE GREAT TRIGONOMETRICAL SURVEY OF INDIA.

By LIEUT.-COL. ALEXANDER STRANGE, F.R.A.S., late Astron. Assistant Great Trigonometrical Survey of India.

THE CHAIRMAN: Allow me to introduce to you Lieutenant Colonel Strange. He has been very much employed in the extensive operations

* I have, in these published Lectures, adhered as nearly as possible to the words in which they were reported by the short-hand writer; they therefore appear couched in language of a more familiar character than that which would have been employed in a written composition. They are also, I am sensible, open to another and a graver objection. The important subject to which they relate is treated in a manner at once loose and incomplete. I am anxious to guard against any misapprehension by pointing out these imperfections, which have arisen from my inability to compress within the compass of two hours anything approaching a full and rigorous exposition of so multifarious a branch of scientific research. I would specify two topics of considerable moment, which I was compelled, by mere want of time, to omit altogether, namely, the determinations of *heights* and of *azimuths*.

Regarding these, I can here only say briefly that the element of height, apart from the interest which more obviously attaches to it, is required for the reduction of all geodesical works to one assumed level—that adopted in India being the mean sea level. The Indian heights have been ascertained, by recent independent investigations, to possess a very high degree of accuracy, and the methods by which they have been obtained well deserved a notice which I was unable to afford them. The azimuth, or direction of the true meridian, is also an element without which no geodesical operation is complete or serviceable. The method by means of which this element is determined in the Survey of India, is only one, but perhaps the most admirable, of those contrived and brought into practical use by Sir George Everest, to whom that department owes all its accuracy of principle and procedure. I believe it is not saying too much to characterise this method as the most perfect solution of a problem known to practical astronomy; but, as it is impossible to give an adequate idea of its elegant precision without entering into details unfitted for an elementary lecture, I judged it best to omit this part of the subject, rather than present it in a loose and mutilated form.—A. S.

of the Great Trigonometrical Survey of India, of which many of you may have heard. They are the most extensive trigonometrical operations that have ever been conducted in this world. India, as you are aware, is not a very small country compared with England and Ireland; and there has been an immense deal of skill and knowledge employed in surveying that country accurately. The survey was commenced in the year 1799 under my master, the late Colonel Lambton. I succeeded him, and I left it in 1843; since that time operations have been going on continuously, and they have been conducted with a great deal of labour, intelligence, and zeal, not surpassed, if they be equalled, in any other country. Colonel Strange has taken an active part in these operations. You may have heard that there has been an extensive series of triangulation carried over that part of the country which extends from Sironj to Kurrachee. It was a very extensive operation, and was carried through (what might be called) *terra incognita*, because, a few years before that time, no European who valued his head would have ventured into those countries. The greater part of this work was executed by Colonel Strange. Operations of this kind, you know, are looked upon by the natives of India with an eye of suspicion, perhaps not altogether unwarranted. They look upon them as a prelude to taking possession of the country, and they give you a gentle hint that you had better take yourself off, if you wish to preserve your head upon your shoulders. I will not trouble you with any further observations, but call upon Colonel Strange to address you.

Lieut.-Col. Strange: It is with very much pleasure that I undertake to give here two elementary lectures on the subject of Geodesy, principally because it is a subject which I believe is very little known to non-professional persons. The word "Geodesy" relates to that branch of science by means of which the size and the form of the earth are determined; the *form* as well as the *size*. To many of my hearers, perhaps, this introductory definition will not have a very promising aspect. It may sound dry, and to savour of technicalities and abstruse mathematical calculations, which, perhaps, to the ladies who have honoured me with their presence especially, may not promise much interest. Yet I am in hopes that they will find, as we go on, something to attract them in it. I can assure them, that, if they are not entertained by this subject as much as by some others which are occasionally discussed in this theatre, it will not be on account of any intrinsic defect in the subject itself, but it will be owing to some defect in the person who is treating of it.

I have said that Geodesy deals with the *size* and *form* of the earth. Now, the first idea that would occur to anybody who undertook to measure the globe which we inhabit would be, that its enormous bulk would alone present a very formidable obstacle to its measurement. Another obstacle is presented by the circumstance that we are on the surface of the globe, and that we can never at one moment get a general view of it. In point of fact, it is easier to determine the size of the sun or the moon, or of many of the planets, of which we can obtain a general view, than it is to determine the size of our own earth. Albeit we cannot determine the size of any of these planets without knowing first that of the earth. Now the earth, speaking in general terms, is about 8,000 miles in diameter. In order to give some sort of idea of this immense body, I will mention one

or two facts relating to it which may assist our perceptions, drawing a comparison between it and this terrestrial globe here, which is about 2 feet in diameter. The highest known mountain in the world, named, after our distinguished chairman Sir George Everest, "Mount Everest," is 29,000 feet in height. To represent that mountain on this globe in its proper proportions, you will have to make it a little more than the hundredth part of an inch in height. It will be a speck of sand, which, at the distance of a few feet, will be invisible altogether to any eye. Take, again, a more familiar object than Mount Everest; take St. Paul's cathedral, which is 404 feet in height. Now that great edifice represented in due proportion upon the globe before you would be the $\frac{2}{10000}$th part of an inch in height, a quantity which would require a powerful microscope for its perception. Compare now these enormous objects, this stupendous natural object,—a mountain 29,000 feet high,—and this great cathedral, one of the greatest of man's works,—compare them with such instruments as we have for the purpose of our measurements, with such, for instance, as you see upon this table, which are not much smaller than those with which the earth is actually measured. The bars that you see before you are just half the size of those with which the greatest geodesical works have been accomplished. This theodolite is certainly smaller than those that are used in first-class operations. It is about one-fourth the size; still multiply that by four, and these bars by two, and then consider what an undertaking you have before you in order to measure this globe, 8,000 miles in diameter, with such appliances.

Besides that of size, there are difficulties presented by the natural conformation of the earth,—by its mountains, its rivers, its forests. Anybody undertaking to measure a room or a road, could, with the use of mere common sense, accomplish his object with a rope or measuring tape, or a rod of wood: he would find it difficult to measure across country with such means, but still he might do it. In fact, measurements have been carried on to a considerable extent by such appliances in linear measurements, as they are called. But when you get to the ocean you are certainly stopped; for it will be impossible to lay bars, or tapes, or rods, or chains along the ocean, to measure, for instance, the width of the Atlantic. Therefore, a direct measurement of the entire circumference of the globe, as generally accomplished by ordinary common-sense people, is manifestly out of the question. Fortunately we have other means provided by geometry. We have the *properties of geometrical figures*, and by their means we are enabled, when we have measured a small portion of a known and determinate figure, to infer the dimensions of the whole.

Now, a circle is one of these. I will introduce the method of employing the properties of that well-known figure, by first supposing the globe to be made up of an infinite number of circles, that is to say, of a form truly globular, which means that it is the same width, the same diameter, in every direction. The terrestrial globe before you represents our earth. Let us imagine this brass ring actually existing in nature, encircling the earth somewhere or other, if we could only find it. Let us suppose, too, that this brass ring has been divided into so many parts, and that marks have been made, or poles have been erected upon it at certain equal distances, and that there are 360 of these poles on the circle encompassing

the earth. That is the number of degrees into which mathematicians divide the circle. It is an arbitrary number; one number of divisions would be as good as another for the purpose we have in view. Let us suppose that this circle has 360 such divisions, called degrees, in it, and that at each degree there is a tangible visible mark; nothing would be easier, if such were really the case, than to determine the size of the globe. Assuming, as we have, that all these marks are equi-distant, we should simply have to measure the distance in feet between any two of them, which would be a small portion of the earth's surface, and multiply the number of feet which we should find between any two such marks by 360; we should then have the circumferance of the circle in feet. It is a very simple problem in mathematics, from the circumference of the circle, to ascertain with any required accuracy its diameter. We should, therefore, by simply obtaining the measure in feet of one degree across a level plain, be able to determine the size of the globe. We owe that facility entirely to the properties of geometrical figures.

We have assumed the earth to be globular. There are good reasons for the assumption. Wherever we go, when we can command a fine, clear, and extensive prospect, we perceive that the horizon is apparently circular. In whatever part of the globe we may be when our view is unobstructed by mountains, trees, or other elevated objects, and particularly at sea, we have a well-marked line defining a circle all round us. Now, it can be demonstrated that such a state of things can only exist on a globular body. Another ground for the assumption is, that in lunar eclipses we see that the shadow of the earth cast by the sun upon the moon is always circular—it is always part of a circle. That also implies that the body casting the shadow is globular; therefore the assumption is apparently a perfectly fair one.

I have pointed out how, by means of marks on the earth, we could, having measured the distance between two of them, determine the size of the whole. But these marks do not exist unfortunately, and we must find a substitute for them. That substitute is afforded by the stars in the heavens. I will endeavour to explain how they are used as substitutes for our hypothetical marks upon the earth. If we go out on a fine night and look at the heavens, and watch them for some hours at a place where we have a clear horizon all round us, we shall perceive (I am supposing that we are in the Northern Hemisphere) that certain stars rise exactly due east of us and set exactly due west; that other stars rise a little to the north of east and set a little to the north of west, and so on till we get to stars more near the north. These we shall find neither rising nor setting, but at all times visible above the horizon, and performing a clear circle round a certain fixed point in the heavens. As we look at stars nearer and nearer to the north we find the circles described by them diminishing, till at last there are some stars the circles performed by which are so small that, without assistance, the eye cannot tell that they are moving at all.

Now, let us suppose the earth to be perforated. The terrestrial globe before you revolves on two points of an iron rod running straight through it, called its axis. Let us suppose that in the direction of this axis the actual earth has a perforation, a hole from north to south through which you may see clearly. Suppose the eye at the south end of this aperture;

looking through, your eye would fall on a certain point in the sky. You would not there perceive any star; nature has not placed one precisely on that spot, as it so happens. But, for the purpose of illustration, we will suppose there is a star exactly in a line with the imaginary perforation. Now, suppose an observer to stand at the North Pole (where no human being has ever stood yet): standing there and looking about him, he will see this imaginary star of ours exactly over his head and immoveable—it will never move at all, day or night, but will form the centre round which all other heavenly bodies revolve. Now, imagine another observer standing on the equator, that is to say, midway between the North and South Poles. Let him gaze about and search for this star, and he will find it, not above his head, as in the former case, but exactly on his horizon. Now, suppose the observer at the equator, on his journey to join his friend at the North Pole, travelling straight along the meridian due north, and watching this star as he goes, he will find, as he advances northwards, that the star will rise; and that, when he gets half-way to the North Pole, the star will be exactly half-way between the horizon and the point above his head. He will go on until he joins his friend at the North Pole, and there they will see the star as before, precisely over their heads.

We see from this that such a star affords the means of informing the observer in what part of the earth he is situated; and it is by means of that information that we are able to substitute for the supposed marks on the earth the stars in the heavens. For I have imagined in this description that there is only one star and that it is in a particular place. There are many stars, as we know, but none there. But what is true of that imaginary star is true of every star actually in the heavens; that is to say, the change of position in the observer produces precisely the same effect or change upon every star in the hemisphere as was produced on our imaginary star. Therefore, any star is sufficient to afford us the means of ascertaining whereabouts we are on the globe; that is to say, of determining our *latitude*, for that is the point to which we have arrived.

Now, supposing that with this knowledge we prosecute our measurement of the globe. We should first determine our latitude; that is to say, we should find at a certain spot on the earth how high above the horizon a particular star stood. We should then go on with our measurement by whatever means; and we will say that we stop when we find that the star had increased its altitude above the horizon just one degree. Instruments are capable of telling us that, and, therefore we can ascertain such changes as those which I am describing. The observer then knows that he has moved one degree of latitude along the meridian, and he knows, from the measurement which we have supposed him to have made, that that degree contains a certain number of feet. He multiplies that number of feet by 360, because there are 360 degrees in the circle of which he has measured only one, and he then has the circumference of the globe, from which it is very easy to calculate its diameter.

We have hitherto supposed the earth to be strictly a globe, strictly of the same width, the same diameter, in all directions. A billiard ball might afford an apt illustration of a globe, or a *sphere* as mathematicians call it. But it was not long that this subject had attracted the attention of learned men before it was suspected that the earth was not a true

globe. Newton, who has laid the foundations of astronomical science, with his extraordinary sagacity perceived that a body revolving on an axis at a certain rate, unless of materials absolutely rigid, must alter its shape; and there were reasons for supposing that the globe had at one time been in a fluid or semi-fluid state. Under such an hypothesis, he argued that the earth could not possibly be quite globular; that the parts most distant from the poles on which it revolved—the equatorial parts—must be made, by the influence of rotation, to protrude beyond what they would do if the mass were quiescent. He was followed in these investigations by Huygens and other great astronomers. The discovery of the telescope took place about that time, one of which, made by Huygens, was 123 feet long; and with the aid of this wonderful instrument he perceived that the body of the planet Jupiter actually was not globular, but that it was wider in its equatorial parts than in its polar. This afforded an argument of a species which has always had an enormous influence on the human mind, the argument by analogy. Arguing from analogy, the conclusion seemed irresistible that the earth was not globular, but that it was of that figure which mathematicians call an *oblate spheroid;* that is to say, of a form such that the distance between the two points round which the body revolves is less than the distance between the two at right angles to them, in other words, the polar diameter less than the equatorial diameter.

I have said that in measuring a true globe or sphere it is only necessary to measure one degree, and that, with the knowledge of one degree, we can attain to the knowledge of the whole. But that is not true of the *spheroid.* A section of the solid body so called is represented in fig. 1, and is a figure called the *ellipse.* It is not true, if we measure a single part of that figure, that we shall be able to say we know the whole; because all its parts are not equi-distant from the centre, and the degrees will not be of equal lengths in all parts of it. We may consider an ellipse, for our present purpose, to be made up of an infinite number of circles differing in size. Referring to the figure, in which the dark line represents an ellipse, we see that a small circle ABC, whose centre is X, coincides with the ellipse at A; a larger circle DEF, whose centre is Y, coincides with it at E; and a larger still GHI, whose centre is Z, coincides with it at H. The spaces between these circles might have been filled up with others, gradually increasing in size, from A the most, to G the least, curved part of the ellipse, to any number, until at every point of the ellipse a circle was adapted to it. We may consider the ellipse, then, to be composed of an infinite number of circles differing in diameter; and any part of it may be dealt with (that is, if it be a small part) as a portion of a circle.

Referring now to fig. 2, we have two circles, whose centres are respectively X and Z, coinciding with the most and least curved part of the ellipse. On each of these circles an angle of 20° (any angle will do) is laid off,—precisely the same angle in both cases. These angles intercept respectively the arcs AB and CD of the ellipse. We see, however, that the arc CD at the flattest part of the ellipse, which may be considered to represent the pole of the earth, is much longer than the arc AB at the most curved part of the ellipse, which represents the earth's equator. Now these arcs are in fact arcs of a meridian, and CD a difference of latitude of 20° at the pole, whilst AB is a difference of latitude of 20° at the

Fig. 1.

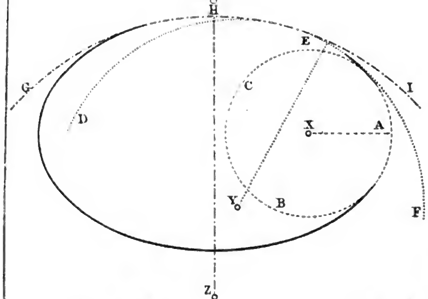


Fig. 2.

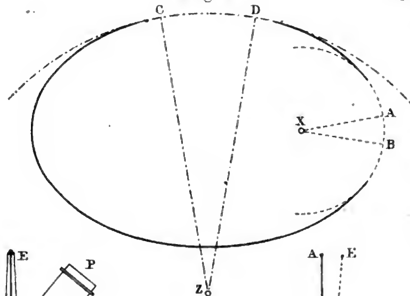


Fig. 4.

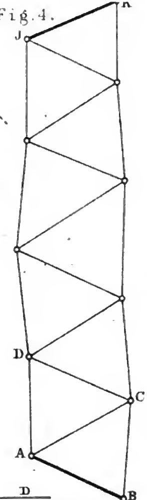


Fig. 12.

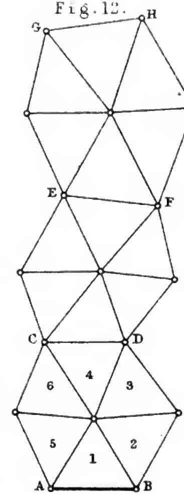


Fig. 3.

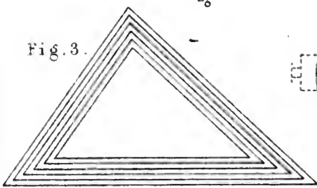


Fig. 14.

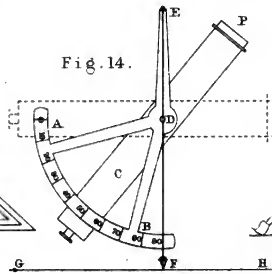
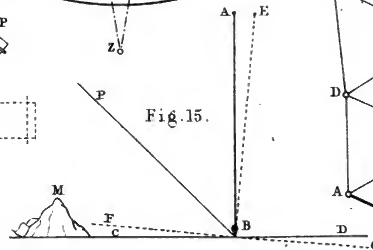


Fig. 15.



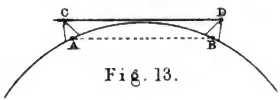


Fig. 13.

Fig. 16.

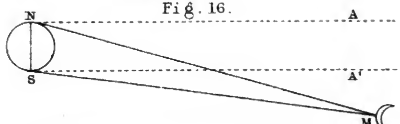
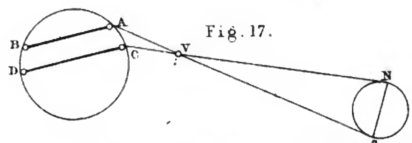


Fig. 17.



J.R. Jobbins.

equator. But it is evident that, at the pole, that difference of latitude corresponds to *a greater number of feet* than the same difference of latitude at the equator. In the figure the ellipticity or flattening of the earth has been much exaggerated for clearness' sake.

If then, in practice, we find, at or near the pole, that one or any number of degrees of latitude contains the same length in feet as the same number of degrees of latitude at the equator, we may conclude that the earth is truly spherical. But if we find that the degree at the pole contains more feet than the degree at the equator, we shall know that the earth is not a true *sphere* but a *spheroid*, and that is precisely what we do actually find. This, therefore, is another example of information indirectly obtained from the *properties* of geometrical figures.

Thus it is apparent, that to measure a true globe or sphere *one* measurement suffices; but to measure a spheroid *two* are indispensable. Yet, though two measurements suffice, theoretically, even for the determination of the spheroid, there are practical reasons for multiplying the experiment, to which I shall not at present allude. Many such measurements have accordingly been made. One in Peru, measured many years ago, was one of the very first executed. It is very near the equator, and, therefore, very valuable. For it is evident, from the inspection of figs. 1 and 2, that the further apart we get the two measurements the better; that is to say, the nearer we get one to the pole, and the nearer we get one to the equator, the better, because the difference between them is then the greatest possible. The measurement in Peru, on the west coast of South America, is, therefore, a very valuable one indeed, because it is on the equator. There is also an arc measured in Sweden, from the North Sea through Russia down to the mouths of the Danube. There has also been one measured in Italy. There is also a very valuable one in France. There has also been one at the Cape of Good Hope, which was measured by the celebrated French astronomer La Caille, whose work our Chairman subsequently revised. There has also been measured an arc of meridian of great importance in India, regarding which I may justly say, and I think without any impropriety, as I had nothing to do with the execution of that particular arc, that it has no equal for accuracy in the world.

Now, having got so far, we see how, by ascertaining the number of feet, and by knowing the difference of latitude between the two ends of the measurement, we can tell the size and general form of the globe. But how are we to make that measurement?

I think very few people will persevere in the attempt to do it in a straight line by means of rods, chains, &c. Such a thing has been done. Such a direct linear measurement, about 100 miles in length, was executed in 1764, along the peninsula between Chesapeak Bay and Delaware Bay in North America, by Messrs. Mason and Dixon, under the auspices of the Royal Society. It was for the purpose of determining the boundary between Maryland and Pennsylvania. They measured with rods in a straight line, and this is the only work of the kind ever executed in that way. The country was favourable. There are very few parts of the world where such a thing could have been done without enormous expense; therefore, direct linear measurement seems to be out of the question in most cases. Now, there is another method which I am aware is well known to many of my audience; but in the sketch which I am giving of these matters

(and time does not admit of more than a sketch) I have been anxious to make myself intelligible to those who are less acquainted with such topics, as I wish them to be as much interested in the subject as my more learned hearers. There is then another method of executing measurements on the surface of the earth called triangulation. A triangle is composed of six parts, evidently. There are three corners or angles, and three sides. Now, if we know the three angles, that is to say, if we know how much the opening at each corner is, we shall know the exact *shape* of the triangle. But we shall not know its *size*, because we can draw a smaller triangle within the first triangle, having precisely the same angles, but sides of very different length. This will be what mathematicians call a *similar* triangle. There may be an infinite number of triangles of that *shape*, all differing in *size*, as in fig. 3. To determine the *size* we must know the length of one side. There is no other way of doing it. It is immaterial which, but one side we must know, and knowing one side, and any two of the other five elements,—either the other two sides or two of the angles, we can then calculate rigorously the *size* of the triangle, that is, the respective lengths of its sides. This is a very simple problem in trigonometry, on which, however, a great deal depends.

To carry on a measurement of the kind about which we are speaking, and which is illustrated in fig. 4, we require first of all to measure the length of one side of a triangle. This side or line is called the *base*. We will suppose the dark line AB to be the base measured in some way—I will describe how presently—that we know its length precisely in feet and inches with the greatest accuracy. Then with instruments called theodolites, such as those on the table, we can measure the size of the angles CAB and CBA. We then have sufficient data to enable us to calculate the length of the two remaining sides of the triangle, viz. BC and AC. That is a very important piece of knowledge to have gained, because the side AC forms a side of the next triangle ACD, and further linear measurement is no longer necessary; the side whose length we have obtained by calculation is as accurately known as if it had been measured. We know then this side AC, and can measure the angles connected with it as before. We can then calculate the sides AD and CD of the next triangle, and so on. I need not go on repeating the process, it is the same thing for each triangle; the power to calculate the sides of these triangles is transferred from one to the other, and there is scarcely any limit to the distance to which triangulation may be thus carried on from one measured base line.

You have here two operations,—the linear measurement of the base, and the measurement of the angles of a chain of triangles. The third operation is the determination of the latitude at the two ends of the triangulation, which I have supposed to run north and south.

Now, that is the way in which the globe is actually measured. A point is fixed upon. A base is measured there on fine open ground, and its latitude is determined astronomically. Triangles are then selected. Their angles are measured with the theodolite, several hundred miles being sometimes traversed by the triangulation. When a convenient point has been attained, north or south of the starting-point as the case may be, the latitude is again determined. Then the difference between the two latitudes shows us what proportion of the earth's circumference we have traversed; and it is very easy, with a knowledge of the length of all the

sides of the triangles, to ascertain the total length of the whole chain. We then know that a certain number of degrees, that is, a certain fraction of the earth's circumference, contains a certain number of feet. This is the result of which we were in search; and it is deduced as correctly, I may say even more correctly, by a measurement made by means of triangles than if made in a direct line with rods.

The measurement of the base is a most important operation, as it is evident that if that be not correct no calculations founded on it can be so. I do not think I am wrong in saying that it is the most delicate and difficult operation known to science. There is no operation in which so much delicate manipulation and such a knowledge of the properties of matter is required as in the measurement of a base line suitable for such objects as we are considering. Accordingly an immense amount of ingenuity has been bestowed upon the subject. Different savants have used different appliances. In the English Ordnance Survey they commenced with wooden rods and wooden frames having very delicate adjustments; they then tried glass rods; they then tried steel chains. All these have been tried: it would take up the whole of the time allotted to me if I were to attempt to describe them. I must, therefore, press forward to the last apparatus contrived in England for making such measurements, of which I beg to show you a model. The subject, I have said, is full of difficulties, and one of the first and greatest is that which arises from the power of changes of temperature to cause the expansion and contraction of every form of matter with which we are acquainted, particularly of metals. Glass rods expand and contract, although very slightly; wooden rods also alter their dimensions, but from causes different from those which act upon metal, and in a less regular manner. It is evidently most important that we should be able to know how much the rods expand and to make due allowance for the error that would creep in from that cause; because, although the operations that I have been describing are, compared with the smallness of our means, very large operations, still, compared with the size of the earth, they are very small, very minute, indeed. And what we have to apprehend is, that, in making an error in a small part of the earth, that error will be multiplied a great many times before we arrive at the entire size of the earth. To illustrate this let us suppose that I make the measurement of a base with a rod ten feet in length, and that at every rod I make an error, from whatever cause, of only the one-hundredth part of an inch; this, by the mere process of multiplication, would cause an error in ten miles of four feet and a half; in the diameter of the earth it would cause an error of 3500 feet; and in the circumference of the earth it would cause an error of nearly 11,000 feet, or more than two miles, and that arising only from an error in each rod very little more than twice the thickness of a sheet of paper. Hence, it is apparent that the operation in question is a very delicate one indeed.

I cannot enter into all the causes that may introduce error in such measurement. The chief one, as I have said, is expansion. I will now endeavour to explain the form of apparatus which has last been employed for overcoming this difficulty. This apparatus is the invention of the late Colonel Colby of the Royal Engineers, and it is well known in the

scientific world as "Colby's Compensating Base-line Apparatus." It is with this apparatus that all the later bases of the Ordnance Survey, and all those of the modern portion of the Indian Survey, seven in number, have been measured.

I should here explain that I have placed this apparatus in a sloping position in order to make it more visible to the audience, and that, when in use, it rests level. I should also explain that, for want of room, I have been obliged to have the model made half the real size. In actual use these bars are ten feet long. Now you see here, fig. 5, two bars, AB and CD, connected in the middle immoveably by a block of metal E, and carrying at their extremities two tongues (as they are called), F and G, at right angles to them. At the extremity of each tongue there is a small dot. In the real apparatus there is a piece of platinum let into each tongue: upon the platinum is made a very minute dot with the finest needle, so minute as to be scarcely visible to the naked eye. The problem requires that these two dots should remain always the same distance apart, in this model five feet, and in the real apparatus ten feet. The bars are represented in fig. 5 in what I may call their normal state, that is, at a certain temperature agreed upon, say 62°; the tongues are exactly at right angles to the bars, and their dots are exactly ten feet apart. Now, the temperature of the air is constantly changing, and it cannot change in the slightest degree without altering the dimensions of almost everything in the world, and particularly those of metals. Accordingly, these bars expand as they get hotter, and the tongues, which before were exactly ten feet apart, become now, under this change of dimensions in the bars, wider asunder, as in fig. 6. That is what would happen if both the bars were made of the same kind of metal. Such a defect would be fatal to our measurement. But by an ingenious arrangement that defect is corrected.

Though all metals expand by heat, all do not expand equally. For a given increase of heat brass expands more than iron, in the proportion of about 5 to 3; that is, the same amount of heat which would make a brass bar expand 5 inches would make an iron bar expand only 3 inches. Taking advantage of this peculiar property of the two metals in question, the bar AB furthest from the dots is made of brass, and CD, that nearest to the dots, of iron. The tongues are not rigidly connected with the bars, but have pivots at *a* and *b* (*vide* fig. 7 on a larger scale) which admit of slight play. The length of the tongues is an important matter. Referring again to fig. 7, the proportion between *a c* and *b c* must be the same as the proportion between the expansions of the two bars, namely, as 5 to 3; in other words, if *a c* is 5 inches then *b c* must be 3 inches.

The effect of these arrangements is shown in fig. 8. The iron bar CD is in the same state of expansion from heat as in fig. 6, but, whilst the iron bar has been lengthening so much, the brass bar has lengthened more, and the two bars being now different in length, the tongues are compelled to assume an oblique direction, which brings the dots at their extremities to exactly the same distance apart, viz., 10 feet, as at first in fig. 5. What is true of the expansion of the bars by heat is equally true of their contraction by cold, so that, if the proportions have been carefully attended to, the dots at the extremities of such compensation bars should always remain

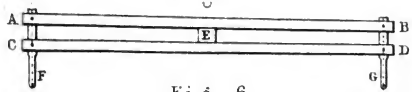


Fig. 6.

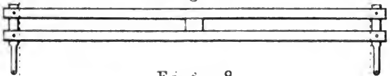
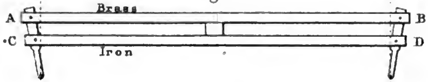


Fig. 8.



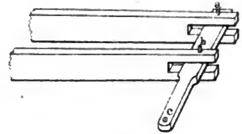


Fig. 7.

Fig. 10.

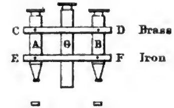


Fig. 9.

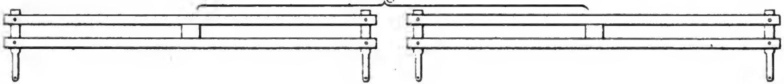
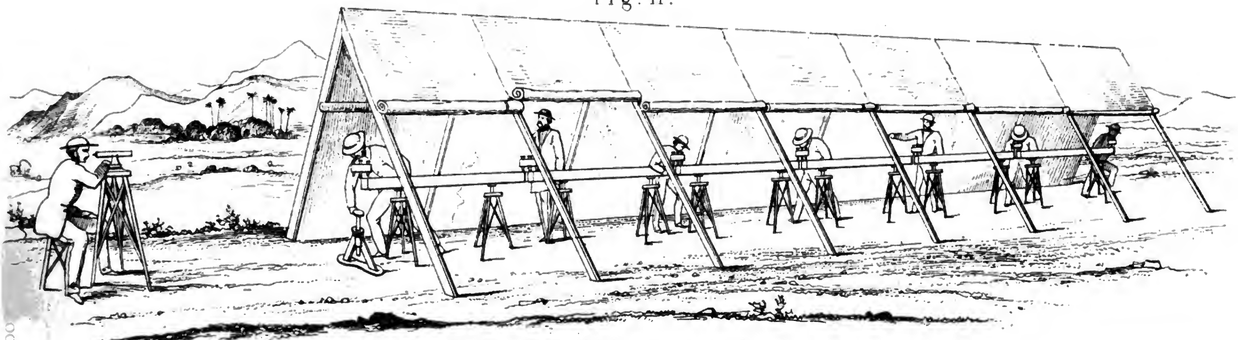


Fig. 11.



MEASUREMENT OF A BASE-LINE,
With Colby's Compensation Apparatus.

J.R.Jobbins

sensibly at one and the same distance asunder. The expansion of the bars and the consequent obliquity of the tongues has been greatly exaggerated in the figure for the sake of clearness.

There remains still another requirement. The measurement is carried on, not with one such compensation bar, as we have described, but with several placed in a line. But there will be a very perceptible interval between the dots on two adjacent bars, as in fig. 9. How is this interval to be filled up? In this manner: Two powerful microscopes A, B, fig. 10, are connected by means of two bars CD, EF. These bars are, one of brass the other of iron, and the length of the microscopes is proportioned to the expansions of the bars, exactly as the tongues were in the case just described. This counteracts the effects of expansion in their case also, and keeps them always at an effective distance apart of 6 inches. A fine cobweb is fixed in each microscope; one microscope is placed over the dot at the extremity of one of the 10-foot bars, and the next bar is then moved up until its dot is under the other microscope, and, the dots being made to coincide with the cobwebs of the microscopes, they must be exactly 6 inches apart. All the bars, of which six are usually employed, are thus optically, as it were, linked together.

The compound bars which have just been described are those which are used for measuring the base, but it would not do to trust to their preserving the same length under all circumstances, as they are subject to a great deal of handling. There is accordingly another bar laid apart expressly for the purpose of testing these measuring bars. It is a bar of iron with very fine dots upon it at its extremities, 10 feet asunder, and it is ascertained how much that bar expands for one degree of Fahrenheit's thermometer—a most delicate operation,—but when once accomplished it is supposed to stand good for ever. Then in the course of the measurement of a base the compensating bars are frequently compared with the standard, and the length corrected thereby, due allowance being made for changes in the standard caused by temperature.

Fig. 11 is a sketch showing how the measurement is actually carried on. These bars, which you now see in the model and figures exposed in order to explain their construction, are in reality encased in long wooden boxes. In practice we use six such bars. Any number might be used, but that is found to be a convenient number. There are six bars and six pairs of microscopes; therefore, the bars being 10 feet and the microscopes 6 inches, the total length of the whole apparatus when put together is 63 feet. You see in the sketch, beginning at the left, first, a bar with a pair of microscopes at the end of it; then we have another bar and another pair of microscopes at the end of that; then another bar and another pair of microscopes, and so on with the whole six. There is an observer at every pair of microscopes, and all these observers act in concert. You must suppose the measurement to be proceeding in a direction from left to right. The first thing to do is to prepare the ground, which is selected as level as possible, and as free as may be from watercourses, swamps, and inequalities, and generally from six to eight miles in length. It is then cleared, and a sort of path made along it, the straightest that can be made, and the vegetation carefully removed in order that the instruments may stand on the solid earth and not be subject to the tremor which would occur if they stood on

roots and grass. Then a special party is appointed to lay out the base along the centre of this ground, in as straight a line as they can make it. They place on this line the supports for the bars, trestles, each bar resting upon two, as may be seen in the sketch. Then another party is detailed to carry the tents; for an apparatus of this sort would be very difficult to use indeed if subject to the heat of the direct rays of the sun, which are never allowed to fall upon it when in use. There are, therefore, tents over the bars. There are two sets of tents, in order that there may be one set ready for the moving on of the bars. The bars then have to be levelled; they are placed upon the trestles. These are provided with a very ingenious brass apparatus for levelling the bars and placing them truly in line. Each bar is levelled; it has three levels for the purpose. Each pair of microscopes is also levelled; then each bar is aligned by the observer (represented at the left of the sketch) with an instrument somewhat like a theodolite, contrived expressly for the purpose, and called a "boning instrument," by means of which he informs any man in charge of a bar whether his bar is to the right or to the left, and they are, with his help, brought mathematically into the same line. Then the man at the rear microscope starts from the point denoting one end of the base—usually a fine dot made in metal imbedded in stone,—he looks at it through the central telescope fixed between his microscopes (G in fig. 10); he moves the bar with the telescope attached to it until the dot fixed on the ground is exactly in correspondence with the spider wire of his telescope. Then the other men move up their bars till the optical connection is made in each case, in the way that has already been described, the aligning and levelling being also maintained correct. At last it is all satisfactorily settled, and the man at the last microscope (at the right of the sketch) adjusts a dot on a solid moveable cast-iron stand, called a "register," exactly under the wire of his telescope. When that is done the bars are taken up, and the dot, which has just been fixed by the man at the right of the sketch, becomes the starting-point for the next set of bars. In that way the measurement is carried on, as it might be, with a pair of gigantic compasses 63 feet long. A system of regular drill and word of command regulates the whole operation, which is more like a military movement than a scientific undertaking.

The base line having been measured, the triangulation is then proceeded with. The instruments are set up at the extremities of the base, and the angles are measured. The importance of accuracy in the measurement of the angles is of course extreme, as the smallest variation in the angles will alter perceptibly the lengths of the sides which compose them. And, if the lengths of the sides are altered, the total length of the whole chain will be wrong. Therefore, very large and delicately-contrived instruments are constructed for the purpose of measuring these angles. The instrument with which the great meridional arc in India was executed had a circle thirty-six inches in diameter; it had a telescope four feet long nearly: it had the most delicate appliances for regulating every part; and it was so ponderous that it took twenty-four men to carry it. That instrument had to be carried up the highest mountains, across rivers and deserts, wherever the necessities of the triangulation decided that it must go.

We call a chain of triangles a "series." A series may be of two kinds, a *single* or a *double* series. Fig. 4 represents a single series, the arrangement of which is very evident; fig. 12 represents a double series. This may look a little more complex, but it is also quite simple when analysed. In the first, the single series, we deal with each triangle separately; in the other, the double series, we treat the triangles as components of the compound figure into which they enter, and deal with each such compound figure independently, completing the calculation of one figure before we proceed to calculate the next. In fig. 12 we have a chain of *hexagons*. In calculating these we have the means of improving and checking our result, by obtaining two independent values or lengths for the sides CD, EF, and GH, which connect the hexagons, and which are called *sides of continuation*. For, starting from the side AB, which we suppose to have been measured, we can calculate the triangles 1, 2, 3, and 4, round by the right, and so deduce the length of the side of continuation CD; this is one value: we can then, starting as before from the side AB, calculate the triangles 1, 5, 6, and 4 round by the left, and so deduce a second value for the side of continuation CD. The two lengths so obtained, in good work, often agree; but there is sometimes a trifling difference, in which case the mean of the two is adopted, as being probably more correct than one would be. Having thus obtained a good value for the side of continuation CD, we employ it as the base with which to calculate the next hexagon, and so on throughout the chain. Though our calculations are not conducted exactly in this manner, the above will serve to show how a double series serves to check the work. Other figures, besides hexagons, such as pentagons, heptagons, and quadrilaterals, are also employed in a double series. The modern works executed in India, since Sir George Everest introduced his system, have almost invariably been executed with a double series. The system entails more difficulty in laying out the triangulation, and a greater amount of labour, but it greatly diminishes anxiety by affording very satisfactory proof, as the work proceeds, of its exactitude.

I will not detain you much longer. I have one point more to dwell upon, and then I have done for to-day. When our triangulation crosses hills we are, as it were, surveying *on velvet*. We have there natural eminences from which we obtain a fine and distant view; we are placed in a pure atmosphere, and our signals are easily seen. It is a very agreeable work, indeed, to carry on in a fine country, if there are hills. If there are plains it is different. A very great portion of Sir George Everests's triangulation in central India was across extensive plains, where the country is one dead monotonous level for hundreds of miles. Under such circumstances we are placed in a dilemma. Let fig. 13 represent a portion of the globe; let A be a point selected for the end of one of the sides of the triangles; let B be another at the other extremity of that side. Now, it is perfectly evident that these two points cannot be seen from each other, as they should be, because the rotundity of the earth intervenes. We are therefore constrained to build at each point a tower; and the observer, with his instrument C placed on one of the towers, can then see an object D placed on the other. In the plains, therefore, at the extremities of every side of each triangle, it is necessary to erect massive towers, from 30 to 150 feet high, according to circumstances, and of such

proportions as to fit it to bear many observers, six or eight men, a considerable tent, and the large ponderous instrument of which I have spoken, and capable of bearing all that weight with the extreme immobility required for taking excessively delicate observations. This adds greatly to the difficulties, the anxieties, and the cost of the work.

I shall not dwell now upon the method in which the latitudes are determined, as it would occupy too much space; but they are determined by astronomical means. Sir George Everest, in order to ascertain what difference of latitude there was between a point near Beder, a well-known town in India, and a point near the foot of the Himalayas, took observations with two magnificent instruments simultaneously. There was a party of observers at each instrument, and they observed the same stars at the same moment, thereby excluding many sources of error. Two thousand seven hundred and forty-eight observations were taken to ascertain the difference of latitude between those two points only. I may unhesitatingly assert that no geographical element is so well known as the difference of latitude of the extremities of that arc. I can say this, for I had nothing to do with it; I entered the department after that operation was completed.

The result of operations such as those which I have attempted to describe, carried on in different parts of the world, is simply this: We come to the knowledge that the earth, instead of being globular, instead of being a true sphere, is a little flattened. It is less in diameter between the north and south poles than it is in a line passing through the equator. That difference may be represented by the fraction one-three-hundredth nearly ($\frac{1}{300}$). The equatorial axis is to the polar axis as 299 to 298; not a great difference it is true. The equatorial axis is in miles 7925 and rather more than a half, the polar axis is a little more than 7899 miles. The difference, therefore, between the two diameters is a little less than 25 miles. It is not considered that the enormous labour which is implied by various measurements that have been made in different parts of the globe, of which the above is the result, has been thrown away. On the contrary, more measurements are required to ascertain with still greater accuracy this point. Though there is so little difference in length between the two lines defining the earth's dimensions, still that little difference is of immense importance to astronomy. And the men who have exhausted their strength and bestowed their whole mind upon this subject in order to arrive at what appears but a few insignificent figures, truly deserve well of their fellow-men.

The Chairman: You will agree with me that we ought to return our thanks to Colonel Strange for the luminous and interesting account he has given us of a very difficult subject. To make such a subject interesting at all shows great skill on the part of the lecturer. Very few people could accomplish so arduous a task; for mathematics are, generally, a very dry subject, and it requires a particular talent to be able to overcome that dryness. We return our thanks to Colonel Strange.

Colonel Strange: I am much obliged to you for the kind way in which you have received my remarks. I beg to inform you that the subject, which is by no means completed in this lecture, will be resumed next Friday.

Friday, March 21st, 1862.

Colonel Sir GEORGE EVEREST, C.B., F.R.S., in the Chair.

Lt.-Col. Strange: Sir, Ladies, and Gentlemen.—In the lecture that I had the honour of delivering here last week, I made the assertion that Geodesy is a subject very little known. I wish to justify having done so, as I do not desire it should be thought that geodesists arrogate to themselves any superiority over other scientific persons, or that we claim for our science greater difficulties than belong to all sciences. The fact is, that any branch of science cultivated to the point of perfection, or even to a point near perfection, must be surrounded with difficulties. I believe all, considered in that sense, are equally difficult. Nor do I pretend to say that the scientific investigations we are now considering are more important than other physical or mathematical researches. The various branches of science are only parts of a great whole. They relate to a knowledge of the works of creation; and, as such, every part is of equal importance with its fellow part. But I have to explain why I said that Geodesy was little known, and how it comes to be little known. We see amateurs distinguishing themselves in different departments of science,—in natural history, in chemistry, in geology, in mechanics, in astronomy. We know that, provided the skill be adequate, and the resolution to succeed strong enough, a great deal may be done in science, even with very small means. We know that some of the greatest facts in chemistry, for instance, have been determined and placed on a footing that cannot be shaken, by Woollaston and other great men, with means that in these days would be called the rudest. Woollaston worked with a few wine-glasses and test-tubes. We know, too, that in astronomy private individuals have erected observatories, and have rendered great benefit to science by their discoveries and researches. I need only mention Lord Rosse's name, Mr. Groombridge's, Mr. Lassells's, and Dr. Lee's, to show that an amateur may vie in the excellence of his results with even professional establishments. But there is this difference between Geodesy and most other branches of science—that it cannot be prosecuted with small means, and that I believe is the reason why it is so little known. Geodesical operations are necessarily carried on upon a large scale. I spoke to you of measuring degrees of the meridian, not one degree, but many degrees, traversing hundreds of miles. Such operations require a large force of men, most expensive instruments, and the whole maintained for many years. They also require that free access should be given into the dominions of adjoining nations. Political considerations, therefore, are brought into action. The result is that it is a branch of science closed to individuals, and which can only be prosecuted by the resources of a state. That is the reason, I apprehend, why so little is known of Geodesy. And as there are no private cultivators of the science, and therefore but a small demand for its literature, the books that treat of it are, almost without exception, of a dry professional character.

I think, before entering upon any new matter, I ought to recapitulate

briefly what I laid down in my first lecture. I first showed that the earth, if a true *sphere*, can be measured by means of one geodesical arc. I then showed that, for a *spheroid*, which it is, two arcs are absolutely indispensable. I also showed that each arc consists of three distinct parts—two latitudes, one at each end, the base, and the triangulation. I did not dwell particularly upon the necessity for ascertaining that such operations are accurate; nor did I touch upon the tests that are applied to them for the purpose of ascertaining their accuracy. There are principally two tests which are applicable to such works. These tests, like almost every other test in science, are but relative. The first test is the *triangular* test; the second is the *linear* test. The triangular test is this: it is a fact, capable of the strictest demonstration, that the three angles of a plane triangle, that is to say, a triangle described on a perfectly flat surface, if added together, are equal to 180 degrees, or two right angles. When described upon a spherical surface they are equal to that, with the addition of a small quantity, easily determined, called the "spherical excess." Now, here we have a means of ascertaining whether the three angles which we have measured with our theodolite are, when summed together, of the right amount. They should equal 180 degrees, plus a small quantity, which is generally not more than two or three seconds; but, small as it is, it must not be disregarded. Now, this test only shows that the *sum* of the three angles is correct. It does not show that *each angle* is correct, and that must be borne in mind. It is there that the test fails; and it is there that we have no test but that of inference.

Now, applying this test to some works with which I am most familiar, we get this result. In the northern part of the great meridional arc of India, which commences at Beder and ends at the foot of the Himalayas, there are 152 triangles, and it is found that the difference between the sums of the angles of these triangles and the number which they should represent, that is, the average error of all those triangles, is not quite nine-tenths of a second. Now, a second of arc is a quantity so very minute, that very few, I suppose scarcely any but professional persons, have ever appreciated it. The average of this great work gives an error of about nine-tenths of a second. If we distribute that equally between the three angles, then the average of the angles may be inferred to be true within three-tenths of a second, which is an excessively minute error.

Another work, the greater part of which I had the honour to execute, was the "Great Longitudinal Series," which commences at Seronj, in Central India, and terminates at Kurrachee in Scinde. It is about 670 miles long, and it contains 173 triangles. The triangular error was a fraction less than what I have just stated, showing the great consistency in these operations, carried on, as they all are, on the same system. That is the *triangular* test, and when applied to a large number of triangles it is a very trustworthy test. But still, as I have observed, it is not conclusive with respect to any one angle.

The linear test is different. I purposely avoided, in my first lecture, referring to the fact, that, in all geodesical operations, it is usual not only to measure a base line at the commencement of an arc or series, but also one at its termination. Both are represented in fig. 4 by the dark lines AB and JK. The reason for having two base lines measured is very

simple. The operations, we will say, commence from the base AB, which is called *the base of origin*. The triangles are carried on northwards, and computations are made of the lengths of the sides of every one of the triangles of the chain, extending in some cases over six or seven hundred miles without a single linear measurement being made, that is to say, a measurement of feet and inches, not one; until, in a favourable locality, another base line, JK, called the *base of verification*, is measured, corresponding with the side of one of these triangles. If there is any important error in the work, it will be found that the length of the side of that triangle given by the calculation, and the length of the same side given by the actual measurement, will differ considerably. This is the *linear* test. It generally exposes a small want of agreement even in the best works.

Now, in the work in which I was engaged, it was found that the verification in question, at the end of the work, assigned a discrepancy to the amount of one inch and nearly two-tenths per mile of that work, that is to say, that every mile in the work, instead of being exactly one mile, was one inch and two-tenths less than a mile. In the great meridional arc the errors were even smaller. In the northern section of it, from Seronj to Dehra, at the foot of the hills, the error was only nine-tenths of an inch per mile. In the southern portion, which I think I may say stands without an equal in the world as a geodesical performance, commencing at Beder, and terminating at Seronj, the error was only five-tenths of an inch—half an inch per mile. Now, let any body go into an open plain and set up two fine marks representing a mile, and then by the side of that half an inch, and he would then have some idea, by comparing these two quantities, of the extraordinary accuracy attending these operations.

Then, though that tests the work, it does not test the bases themselves, They may be erroneously measured. We have the means of testing them, into which I cannot fully enter. But one of them consists in the re-measurement of the base. You naturally assume, if you perform the same operation twice and arrive in both cases at nearly the same result, that in both cases your work has been well executed. A base was measured at Dehra, at the foot of the Himalayas, by Sir George Everest, and it was re-measured. It was about seven miles and a half long. The first measurement and the second measurement were taken in very different seasons; it was very much hotter during the one measurement than during the other—a severe trial to such an apparatus as was used. The result was that the two measurements differed, that is to say, the seven miles and a half in the one case and in the other differed by two inches and three-tenths. That error, Sir George Everest, in his work on the subject, with great justice, presumes to have been in some degree caused by the compensating apparatus which I alluded to in my last lecture not being perfectly compensated, for the direction of the error coincided with the increase of the temperature. It is a curious fact regarding this apparatus that it is not found to be permanent in length. It has now been in use twenty-five years; it has been constantly compared with the standard bar; and, though the six measuring bars added together never did exactly equal the standard bar multiplied by six, that is of no consequence, provided we know how much the difference amounts to. But the difference should be permanent, it should be the same at all times in a

given temperature, and it is not found to be so. It is found to have increased in the course of twenty-five years by about two-hundredths of an inch —a quality which is made so clearly perceptible that there is no question whatever about it. And the only question that remains to be decided is, Has the standard bar shortened, or have the compensation bars lengthened? That is a question which I believe science is unable at present to answer decisively.

Now, I mentioned in my last lecture that many arcs had been executed in different parts of the world. The question may naturally arise—having measured two arcs, with which theoretically the form and size of the earth can be ascertained—why measure more? There are two reasons for it, two particular reasons. One is this, that we cannot be certain that the earth,—although we know it in general terms to be what mathematicians call an oblate spheroid,—we cannot be certain that it is quite symmetrical, that all sections of the earth through the poles will in every instance give a perfect ellipse of the same size. There may be parts where the ellipse bulges more than in others, and other parts where it flattens; and it is reasonable to apprehend that such is the case, because we do not suppose that the earth is of the same density throughout, a condition indispensable to symmetry. The causes which made it elliptical, namely rotation in a semi-fluid state, may have made it unsymmetrical. That is one reason. The other reason is that the absolute latitude, determined astronomically, is subject to one source of great uncertainty. Newton laid down the law of universal gravitation, "That every particle of matter in the universe attracts every other particle with a force directly proportionate to the mass of the attracting particle, and inversely to the square of the distance between them." That is to say, that everything in the earth tends towards every other thing, that the tendency of one object to attain to another is dependent partly upon the weights of the two objects and partly upon their distance asunder in the mathematical ratio which I have just stated.

I said in my first lecture that the latitude is equal to the angular elevation or altitude of the pole above the horizon. But what is the horizon? At sea the horizon is a well-defined circle round the observer, and it is easy to conceive that the altitude of the pole (supposed a visible point in the heavens) may be measured by taking this circle as a fixed point from which to measure. But on land we have no such defined horizon—mountains, trees, &c., intervening, or haze obscuring our view. On land, then, we must have recourse to other means; and accordingly we use the spirit level or the plumb-line for the purpose of indicating where the horizon would be if visible. The plumb-line, though now seldom used in astronomical instruments, will best serve our present purpose of explanation.

In fig. 14 let AB be a metal quadrant graduated to degrees from 0° to 90°; C a telescope moving round the centre, D, of the quadrant, in a vertical plane; EF a plumb-line suspended from a support forming part of the instrument; and GH the plane of the horizon, supposed not visible. The property of the plumb-line is to hang in a vertical direction, that is, perpendicular on all sides to the horizon; in other words, the angle formed by the plumb-line and the horizon is a right angle, or 90°.

It is evident then, as we know the angular relation between the plumb-line and the horizon, that the former may be substituted for the latter, and so employed on land when the horizon is not available. Hence, if we adjust our quadrant so that the plumb-line shall exactly coincide with the 90th degree cut on it, as in the figure, and then raise the telescope to the 0° or zero of the quadrant, as indicated by the dotted lines, it will be at right-angles to the plumb-line, and will point as exactly in the direction of the horizon as if the horizon and not the plumb-line had been visible and employed for the purpose. If now we direct the telescope to P, the pole (supposed a visible point in the heavens), as in the figure, and note the degree on the quadrant to which, when so directed, it is opposite, say 50°, we shall know that that is our latitude, that is, as was before explained, the angular elevation or altitude of the pole above the horizon of the station of observation. I have stated the matter in the simplest possible form, divesting the problem of numerous minor considerations which have to be attended to in actual practice.

I have here supposed the plumb-line to be acted upon by gravity equally in all directions, and therefore to hang vertically, as in such normal circumstances it would do. But if the action of gravity should not be equal in all directions, it is evident that the plummet, being free to yield to any predominating attractive influence, would no longer hang vertically below its point of support. Now experience has shown that such equality of action does not always exist. High mountains in the vicinity of the station of observation have been found to disturb this equality, and very perceptibly to deflect the plumb-line from its true vertical direction in obedience to Newton's universal law of gravitation above enunciated. Let us see how this will affect the latitude.

In fig. 15 let AB be the true direction of the plumb-line, CD the true plane of the horizon, and P the north pole. Then the angle PBC, being the altitude of the pole above the horizon, will be the true latitude. Now suppose a mountain, M, to exist to the north of the station, its mass and vicinity will attract the plummet and cause it to assume the oblique direction EB, and the horizon will thus be made to appear in the position of the dotted line FG, instead of the true one CD, and the latitude or altitude of the pole will be PBF instead of PBC, which will be erroneous to the extent of the inclination of the incorrect and true horizons, *i. e.* the angle FBC. In this case the latitude will be *diminished* to that extent by the disturbing influence of the mountain attraction. If the mountain had been to the south, the latitude would have been *increased*, and the reverse effects would occur in the southern hemisphere. As an actual example of such influences, I may mention that the latitude of Dehra, a town at the foot of the Himalaya mountains, was found to be erroneous, as determined astronomically, to the extent of nearly 38 seconds of arc, an error which, had that point been made the termination of an arc of meridian one degree in length, it would have made the earth's diameter about 82 miles too small: care, however, was taken to fix upon a termination for the Indian arc of meridian as remote from these stupendous mountains as circumstances would admit. But, even as it was, the point selected, though about 70

miles from the Himalayas, still proved, to a small extent, within the influence of their attraction.

Though mountains are the most obvious and most energetic agents in disturbing astronomical latitudes, other causes produce similar effects: masses of matter out of sight under the surface of the earth, if differing in specific gravity, being sufficient to introduce error by causing the deflection of the plumb-line.

There can never exist any guarantee that, in a given locality, some disturbing agency may not occur. The only way in which the natural difficulty can be overcome is, by making measurements in as many parts of the world and in circumstances as various as possible, in order that an error arising in one locality may be counteracted by a contrary error in some other quarter, and so a fair average be obtained. And this is one of the chief practical reasons for multiplying such measurements.

Fortunately the measurement of the angles of a triangle is not affected by these causes in any sensible degree whatever. Therefore triangulation marches ahead perfectly correct, so far as Nature is concerned,—she only interferes with the determination of latitude.

Now geodesy, besides affording a knowledge of the size and form of the earth, has been applied to another use by the French nation, namely, for establishing a *unit of linear measure*. It may be asked, What is a unit?—In this sense the word means a fundamental measure of length, as an inch, a foot, a yard, of such definite extent as to convey a perfectly precise idea of its length. But to say that a certain thing is a foot long does not convey any definite idea, because one foot may differ from another. If anybody will take the trouble to examine a number of ordinary foot rules, he will find among them very large differences, at all events, very perceptible differences. Therefore, to say *a foot*, means nothing in science, and different people have accordingly had different ways of fixing the idea of the foot or the yard. The English refer it to the pendulum. The connection between the pendulum and the foot is not at first sight very obvious; but, when we consider that the rapidity with which a pendulum swings is dependent solely upon its length, we then perceive how that rapidity may be used as an indication of length. A long pendulum oscillates more slowly than a short one, in a certain ratio well-known to mathematicians, which I need not dwell upon. Now the mathematician's conception of a pendulum is that of a body the whole of whose weight is concentrated in a single mathematical point, that body being suspended by a rod or string, totally without weight, and from a joint in which there is no friction, the whole being in a vacuum. I need not say that these are circumstances which cannot be commanded in actual practice; but if we know the size and the weight and form of the body of the pendulum, if we know the size and weight of the rod, if we make careful experiments upon friction, and if we know the amount of air that there is in the receptacle in which the whole moves; if we know these, we can reduce by calculation the results given by that pendulum to those which would be given by a perfectly mathematical pendulum. Such a pendulum will move with different velocities in different parts of the globe. The globe rotates on its axis. In doing so it generates what is called the centrifugal force—the tendency to throw

things away from it. That force acts in opposition to the central force of gravity, of which I spoke just now, which attracts everything to the earth. Now the attracting force we will assume, for our present purpose, to be constant, the same in all parts of the globe, but the centrifugal force must be greater at the equator than at the poles, and, as it is gravity which keeps the pendulum in action, this variation in its effect, caused by the centrifugal force, will compel the pendulum to move at different rates, according to the latitude of the station at which it is employed. We find that at the equator a certain pendulum will make 86,400 oscillations in one mean solar day. We find that in London the same pendulum will make 86,535 oscillations in the same time, the difference being 135 oscillations more in London than at the equator. At the pole it will make 86,640 oscillations, or 240 more than at the equator.

But to come to the matter in hand. In order to accelerate the equatorial pendulum and to compel it to keep pace with the polar pendulum, or the pendulum in London, we must shorten the equatorial pendulum. Most elaborate experiments and calculations have been made on the length of the pendulum, and the result is, that the mathematical pendulum—this imaginary perfect pendulum—oscillates exactly at the rate of one second per oscillation in London in a vacuum, if it is 39·13911 or $39\frac{1}{7}$ inches (nearly) in length. Hence we have in the pendulum an unchangeable means, afforded by Nature herself, of ascertaining a linear measure or unit. Provided we attend to all the conditions necessary to success, we can at any time go to Nature and ask her what the foot is, and she will reply to us truly.

It is a very awkward number, the number I have just given you; and I presume this has arisen from the arbitrary adoption of the foot before its scientific determination.

The national standard yard measures were destroyed in the burning of the Houses of Parliament, and new ones had to be made. Anybody who is interested in this subject should read the account of all the operations connected with the recovery of the national measure given by Mr. Bailey. It is one of the most interesting examples of experimental science that ever was published.

But the French were not satisfied with this means of obtaining a linear measure. They thought it too local; they thought it was not at all becoming in other nations to go to London to find out what their feet were, and that something more universal should be employed for this purpose. Accordingly, the National Convention in 1791 selected this method: They deduced from their geodesical operations the length of a quadrant of the meridian passing through the Observatory of Paris; that is to say, the distance from the equator to the pole on a meridian passing through the Observatory at Paris; and they took of this one ten-millionth part, and they called that a *mètre*. Now, we have seen a little of the difficulties of geodesical operations, and we have seen that such works are burthened with errors arising out of natural causes over which we have no control, such as irregular attraction. Therefore, this method of obtaining a constant length is one the efficacy of which many people doubt. Professor Airy, than whom there is no higher authority on such a subject, says in his Treatise on "The Figure of the Earth," that "the idea of replacing a

lost standard by an extensive geodesical measure is perfectly chimerical." The French and English, therefore, have distinct units; but the proportion they bear to another is well known, and therefore it is quite possible, though very inconvenient, to convert one into the other in any calculations that have to be made with the two.

Now, as to the value of all these works, quite apart from their interest,—as to their practical value to mankind, quite apart from the stimulus that they afford to his imagination, to his admiration of the works of nature—quite apart from those higher sentiments,—what is the value to man of such works? how do they affect his well-being? The answer is very simple indeed. Commerce is indispensable to man; navigation is necessary to commerce; navigation is dependent on astronomy; and astronomy, as it is at present received, could not exist if there were no geodesical works. Having said that, I think it is quite clear that men owe something to geodesy.

The particular use that is made of geodesical measures in astronomy is this: they afford the basis of all astronomical distances. No astronomical distance can be determined without a previous knowledge of the size of the earth. I will illustrate this by a diagram in which the distance of the moon is determined. So slight an explanation as my time permits me to give can convey, of course, but a very imperfect idea of the delicacies required in such a proceeding; but still the main outline of the problem may be made tolerably clear in a few words. In fig. 16, the circle represents the earth, N the north pole, S the south. Imagine, for the sake of illustration, that it were possible to erect observatories at the north and south poles, and to keep men alive there to take observations. The earth is so infinitely distant from the stars, that a line drawn from the north pole to a given star and another line drawn from the south pole to the same star, will be sensibly parallel, owing solely to the immense distance of the star. The nearer the star might be, the more tendency there would be in those two lines to converge; but in reality, they do not sensibly converge, and they may be taken as strictly parallel. Therefore, you understand that the two dotted lines AN and A'S, if extended a sufficiently great distance, would touch the *same* star. Let M be the moon. Connect her with the earth by the lines MN, MS. You perceive that a triangle NMS is formed. How can we calculate the length of the side of that triangle from N. to the moon, or from S. to the moon? If we can do that, we shall know the distance. It is very simple. The astronomer at the north pole measures with an appropriate instrument the angle ANM contained between the star and the moon. He knows that the angle contained between the star and the axis of the earth is a right angle. He subtracts the measured angle ANM from the right angle ANS, and the result is one angle of the triangle, viz. MNS. The observer at the south pole measures also the angle A'SM, between the moon and the star. Here again he has a right angle contained between the axis of the earth and the line drawn from himself to the star. But the moon being below that line, he must add this observed angle to the right angle. He, then, has another angle of the triangle, viz. MSN. We know from our geodesical operations exactly the distance between the observers at the north and south poles, that is the polar diameter of the earth. Therefore, in the

triangle MNS, we have obtained from observation the angles MNS and MSN, and, the length of the side NS being known from geodesy, we have three elements of a triangle—one being a side, which, as I explained in my first lecture, suffices for the deduction of the other two sides, NM and SM, which represent the distance of the moon from the earth; a result, however, which we could not obtain without a knowledge of the earth's dimensions.

The sun's distance is determined by a process much more complex. There are several ways of doing it, but the most trustworthy method is by means of the transit of Venus. At certain periods the planet Venus gets exactly between the earth and the sun, and is seen to pass across the sun's disc as a small black spot. I shall not enter into this problem; it is totally impossible in the few minutes at my disposal to do so. It is explained in a course of lectures given by Professor Airy at Ipswich, in 1848, and he devotes nearly a whole lecture to it, and that an elementary lecture; and, after having explained it in his usual lucid manner, he states it as his opinion that it is the most difficult subject he knows of for a public lecturer. Without attempting a full explanation of this beautiful but complex problem, I may show you in what it consists. In fig. 17 the large circle represents the sun; NS the earth with our friends at the north and south poles as before; and V is Venus, between the sun and earth. Now, the gentleman at the south pole will see Venus projected as a black spot on the sun, in the direction SA; he will see Venus enter upon the sun's disc there, pass across it, and make its exit at B. Let us suppose that Venus leaves a visible line AB on the sun's disc along her path, as seen from S. The gentleman at the north pole sees Venus enter the sun's disc at C, and emerge from it at D, leaving, we will suppose, the visible line CD parallel to AB. Now, the width of those two lines apart will depend partly upon the *size of the earth*, and partly upon the distance of the sun from the earth. We can ascertain their distance apart by noting the time which it took the planet to describe the paths AB and BC respectively, the observers at S and N being very careful to record the exact times at which they saw the planet enter and leave the sun's disc. With these measures of time we can ascertain the distance apart of the two paths. I said that this distance will depend partly upon the distance of the sun from the earth and partly on the size of the earth. Of these two things we know one, that is, the size of the earth; we have, therefore, data for calculating the other, and that is all I can say at present about it. Here again, you see, that a knowledge of the dimensions of the earth is indispensable to the solution of the problem; and this knowledge geodesy alone can supply.

My audience, no doubt, are familiar with Cook's famous voyage to Otaheite. It was undertaken for the express purpose of assisting in the determination of this problem. It occurred in 1769. The next transit of Venus will happen on the 8th of December, 1864. It is predicted now, and, owing to the perfection of astronomical and geodesical science, it is as certain as that to-morrow is Saturday, that it will take place then.

Now, having the sun's distance, we can get something useful out of it. What is the sun's distance? It is just half the diameter of the orbit of the earth round the sun. Double this distance, and the result is the diameter of the earth's orbit. Having this distance, we have therefore

obtained for ourselves in the heavens a base line of enormous length. It is one hundred and ninety millions of miles long. I said a little while ago that two lines drawn from the two extremities of the earth's axis to a star would be parallel; but a line drawn from the extremities of the earth's orbit, which is so much wider, may not be quite parallel. It is found in reality that they are not. In some cases it has been just possible, and only just possible, with the finest instruments and with the greatest skill and labour, to ascertain that there is a small convergence of these two lines, by means of which astronomers have calculated the distance of certain fixed stars. They may be taken at twenty billions of miles, which is a quantity that one can mention, but not hope to realise. The distances of the planets are comparatively easy of discernment.

Hence, it appears that geodesy is one of the main foundations of astronomy. Having said that, I have said quite sufficient to assert its importance to man—its practical, utilitarian importance.

Now, there are other ways in which geodesy is useful which I have not dwelt upon. Geography is a science regarding which I need not say much to gain respect for it. It has always been cultivated in conjunction with geodesy. It has always been sought to unite these higher scientific results with results useful to geography. In India, accordingly, that object has been kept steadily in view, and, as I have worked in India, it is natural that I should refer to operations there.

The "Great Trigonometrical Survey of India" was commenced in the year 1799, by Colonel Lambton. He was then a young officer in Her Majesty's 33rd Foot, serving in India. He laid before Government a project for triangulating India. He was a man of great mathematical attainments, and the project was favourably received by the Government, chiefly in consequence of the advocacy of one whose name cannot be mentioned in this Institution without reverence—the late Duke of Wellington, who commanded the 33rd Foot at that time. His comprehensive genius enabled him to see the great value of such a work, and accordingly he gave it his strenuous support, and it was undertaken at his suggestion. There was associated with Lambton a gentleman named Kater, a name familiar to every scientific man in every civilised nation in the world. He subsequently left India, and pursued his scientific avocations in England. Under the auspices of these two famous men the survey of India was commenced. Colonel Lambton measured what we call the southern part of the Great Meridional Arc of India, from Cape Comorin to Beder. It is not my intention to enter into a criticism of that work. It was a most wonderful performance for the day in which it was executed. Colonel Lambton died at Hingun Ghaut, about fifty miles from Nagpore, in January, 1823, at the age of seventy. His fame is held in great respect by all who knew him, and by all who have studied his works.

Lambton was succeeded by our Chairman, Sir George Everest, who had surveyed under him. By that time science had made very considerable strides, and Sir George at once took advantage of all the improvements of the day. He totally re-organised the survey. He came home and had very superior theodolites constructed. So superior are they, that I believe the very theodolite he took out about thirty years ago to India is without an equal in the world at this moment. It was made by the celebrated Edward Troughton; and the graduation, the most important

part of the instrument, was executed by Troughton's own hand. I have worked with it myself most extensively, and I am happy to testify to its great merits in this place. He took out also a new base-line apparatus, that which I attempted to describe in my last lecture. This apparatus has not been superseded yet, but it may be one day. It was then the most perfect thing of the kind that was known. Sir George also took out two large astronomical instruments for the determination of latitude. He introduced improvements for which surveyors in India cannot be too grateful—luminous signals. I have not dwelt upon these details for I have not time to do so. But when I spoke of measuring triangles with a theodolite, it must be evident that I must have intended that there are conspicuous marks of some kind on the different stations by means of which the measurements could be made. Hitherto these marks had been poles or flags, and, in a climate like India, it was difficult to see them except in particular states of the weather. This involved great exposure, and during the rains, the best season for seeing opaque objects, great suffering. Sir George Everest introduced in India a peculiar instrument called the helistrope, a contrivance for directing to the observer the rays of the sun, which then looks like a star in daylight, and can be seen at immense distances. He also introduced a very powerful lamp, which could easily be seen by night. By these means the labours of the surveyors have been much lightened and the accuracy of the work greatly increased. He also introduced new methods of observing and computing, and established one consistent system throughout the department. It was a work of enormous labour, as at the time Colonel Everest entered upon these improvements he had not a single assistant who knew anything about the apparatus he was introducing. He had to train them all. New instruments are causes of intense anxiety to surveyors. They seem like human beings in the number of maladies to which they are subject, and the extremely complex and contradictory nature of many of their symptoms. No man can successfully pursue geodesy in distant parts unless he is something of an instrumental surgeon.

I have so little time left that I must pass over many subjects which I wished to touch upon. I should particularly desire to bear my testimony to the great necessity for system in surveying. I will illustrate it in this way. A workman has to make a chess-board containing sixty-four squares. Suppose he calls sixty-four workmen to him and orders each man to make a separate square. He tells them that the squares are to be one inch each way, and to be one-tenth of an inch thick. The men will all bring their squares. Will they fit? Most undoubtedly not, however skilful the workman may be. There will be an overlapping in one place, an hiatus in another, and so on. The conception formed by one mind of an inch and by another mind of the same measure will not be the same. The conception formed of a right angle by one mind and by another will not be the same. The thicknesses will also differ. The three elements will differ, and there will be a mass of confusion. But if a man makes all the squares himself according to rules which he has laid down for his own guidance, or if he employs machines, such as are constructed for making pins and needles and steel pens, repeating the same form with perfect accuracy any number of times,—if he employs a machine like that to make his squares with, then they will fit. Now, that is precisely

illlustrative of surveys. Everybody who has had anything to do with the compiling of maps knows that when he receives materials from a variety of sources he cannot make them fit. It is perfectly impossible. And each surveyor will contend that his work is perfect. Therefore, whose work to alter and how much to alter it, whose work to reject and throw into the fire, who can say? Hence a survey of any large tract of the earth's surface must, in order to give it any value at all, be executed upon one system. There must be one mind—I do not mean one mind throughout, but there must be the impress, as of one mind, upon the whole work. There must be the same linear unit, the same foot. There must be the same calculations, and the same method of using the instruments, or the results will clash.

Now the system carried on in India is, I may say, because I had nothing to do with organizing it, a very perfect system indeed. It is my humble opinion that anything which tends to dislocate that system, and to throw the various branches of the work into different hands, will be productive of results which all those interested in such matters will deeply deplore.

I have talked of geographical errors. I have said that men bringing different surveys together will find that their work will not agree always—never will, in fact. I may seem to be over refining. To show that I am not unduly refining, I will mention some errors that have actually been ascertained to exist in geography. Gassendi discovered the accepted length of the Mediterranean to be erroneous to an extent, not of a few inches, but of five hundred leagues. De Lisle shortened Asia by more than twenty-four degrees, a matter of 1,600 miles. The king of France complained bitterly that Casini's great triangulation had deprived him of a very large slice of his dominions. And one of the first discoveries that Lambton made in his survey of India was, that the peninsula in the latitude of Madras was forty miles in error. Now, that distance was determined by two astronomers, who independently ascertained the longitudes of two spots astronomically. They were able men and did their work faithfully, and it just shows what errors may be introduced by absolute astronomical determinations.

Sir George Everest was succeeded by Colonel, now Sir Andrew, Waugh, of the Bengal Engineers; and that officer carried out Sir George's system with ability and industry. He has resigned the service, and he is now succeeded by Major Walker of the Bombay Engineers, than whom a more able man could not have been selected.

Some of the fruits of the survey are these: upwards of 500,000 square miles triangulated rigorously. A meridional arc of 23 degrees, 1522 miles long, executed most accurately. A longitudinal, or arc of parallel, of 10½ degrees, 670 miles long, completed and tested. Besides these, an atlas of India, on a scale of four miles to an inch, which is approaching completion, and which for extent and accuracy leaves nothing to be desired. Any gentleman particularly interested in the subject will see on the charts before me how the results of our survey are given at a glance.* They are well worth examination.

* These charts have engrossed upon them all the geodesical elements, viz. the length of the sides in miles and feet, the latitude, longitude, and height above mean sea level of every station, and the reciprocal azimuths of all stations. They are invaluable to the topographical surveyor.

I wish I had time to enter upon a description of the instruments before you, as perhaps they would interest many more than the dry details which I have given. I must, however, be very brief indeed. These instruments are all theodolites. Now, the object of a theodolite is to measure *horizontal* angles and *vertical angles* with accuracy. It consists of a telescope having freedom of motion in a vertical plane, and also having freedom of motion in a horizontal plane, provided with circles and with adjuncts thereto, which denote how much the telescope has moved in those two planes. That is the general principle of the theodolite. As it stands before you it has a very complex appearance, but the complexities are all secondary; it is an exceedingly simple instrument in its main features. It may be said to consist primarily of three master lines only. There is a line corresponding with the centre of horizontal motion, which we call the *vertical axis;* another line corresponding with the motion in the vertical plane, which we call the *horizontal, or transit axis.* Those two lines must be exactly at right angles to one another. The third line is what is called the *optical axis* of the telescope—the very centre of the telescope. That line must be exactly at right angles to the *horizontal axis;* and it must bear such a relation to the vertical circle that when the commencement of the circle is opposite to the pointer, when the circle reads 0°, then this *optical axis* shall be exactly horizontal. These are the three master lines of the theodolite. Everything else that you see are mere appliances to secure these ends, and to increase the convenience of using the instrument. This instrument has been lent to me very kindly by Messrs. Elliott Brothers; it is a fine instrument; it is constructed more for astronomical than geodesical purposes. In astronomy the determinations of the vertical circle are of more importance than horizontal determinations; therefore, the vertical circle is large compared with the size of the instrument. If it had been constructed for geodesical purposes, the horizontal circle would have been made much larger in proportion to the vertical. It is simply this that constitutes the difference between the theodolite and what is called the altitude and azimuth or altazimuth instrument, of which this is a specimen. This other instrument is very curious, and will bear close examination. It is made by a famous German artist, named Ertel. It has the same general arrangements as the former instrument, namely, horizontal motion and vertical motion. It is very peculiar in its construction. Amongst other things you will observe that the telescope is not over the centre of the instrument, as it was in the preceding case. Foreign observers and makers are fond of this construction, which is called the eccentric construction. It has its advantages. It does not necessitate quite so high an instrument as the other form. But there are reasons, too technical to be now discussed, which make me prefer the form usually adopted by English makers, in which the telescope is placed symmetrically over the centre of the instrument.

Here again we have an instrument made by Troughton and Simms, a 7-inch transit theodolite. It is a very good style of instrument indeed; it is useful both for astronomical and geodesical purposes. You perceive its general features are as like that first referred to, by Elliott, as can possibly be. Here is a theodolite which goes by the name of our Chairman, the "Everest theodolite." It was designed by him, and it has done more good work, I believe, than any instrument that was ever contrived

for the purpose. It is chiefly admirable for its compactness. Here is what is called the "Ordnance theodolite;" not quite with justice, I believe, for I have very great doubt whether the Ordnance are fond of that instrument—I hope not—I do not admire it myself. It is beautifully made, but the design is not such as I approve. We want, above all things, *stability* in such instruments. Stability is one of their chief essentials. The relative stability of instruments may be estimated by means of a triangle formed thus. Take the basis of the instrument, on which it stands, and consider that the base of the triangle. Take the centre of the telescope and call that the apex of the triangle. You have then a triangle of a certain form peculiar to that instrument. Fig. 18 represents the old pattern theodolite (which I am sorry to say is still more in vogue with English surveyors and engineers than it deserves to be); and the dotted lines show what the triangle for estimating its stability will be. Fig. 19 is the Everest theodolite, with its test triangle, also in dotted lines. These are drawings, on the same scale, of two instruments exactly equal in power and range. Compare them. In one the test triangle is *three and a half times* the height of its base; in the other it is *not once* that height. The old instrument has other defects in construction, on which I need not dwell; but the one I have mentioned is all-important.

I wish I could enter further into details, but it is impossible, as my hour draws to a close.

I have now only to vindicate the propriety of delivering these lectures in such an Institution as this. I think I need not say much for this purpose. The objects of Geodesy are, in the first place, of high scientific interest; in the second place, they seek to give us good maps, all the best maps in existence being founded on trigonometrical operations. No military man can doubt the use of good maps, and there can be no good maps of extensive parts of the universe without such works as we have been describing. Naval men attach even greater importance to maps, and well they may. The delineation of the coast line is a matter of life and death to them. But naval men owe more to us than even good maps. There is a book known to every seamen, called "The Nautical Almanac." Next to his Bible, I believe he loves no book so well; and he has great reason to esteem it, for without the help of such a book modern navigation would be out of the question. In that book is contained every astronomical prediction that can be made which is necessary for successful navigation. Now the predictions of that book, as I have endeavoured to show, being deduced in great measure from our knowledge of the distances of the heavenly bodies, could not have been made without the help of geodesical measures. I have, therefore, I think, established that, although every naval and military man need not be, in order to be a good officer, a geodesist, yet, in an Institution like this, which is organised on very enlightened principles, such a subject may possess some interest, and is entitled to consideration.

THE CHAIRMAN: I think I give expression to your wishes in returning our best thanks to Colonel Strange for his kindness in giving this lecture, and for the luminous manner in which he has explained this difficult subject.

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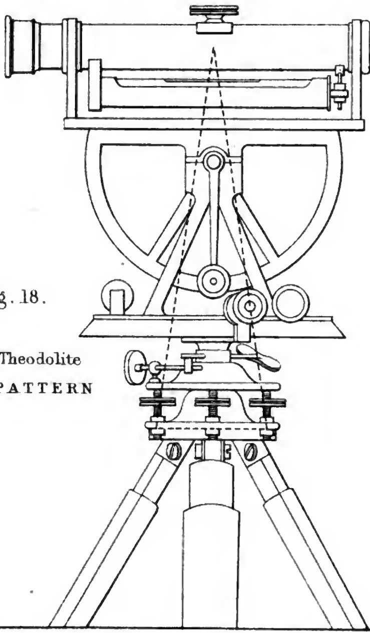


Fig. 18.

5 Inch Theodolite

OLD PATTERN

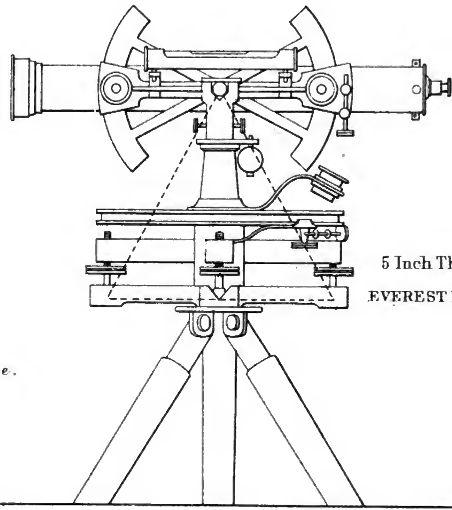


Fig. 19.

5 Inch Theodolite

EVEREST PATTERN.

Scale ¼ Size.

J.R.Jobbins

Friday, May 2nd, 1862.

Lt.-Col. LE COUTEUR, Coldstream Guards, Member of Council, in the Chair.

ON THE USE OF CYLINDERS IN LAYING SUBMARINE TELEGRAPHIC CABLES.

By Captain J. H. Selwyn, R.N.

It so happens that no longer ago than yesterday an article was written to "The Times" on a question which is still occupying public attention, viz., that of the Atlantic Telegraph Cable, although for the moment its accomplishment seems to be rendered more difficult by the unfortunate circumstances which have plunged the American States into the horrors of civil discord.

It will be easily conceded that novelties of structure are then most useful, and are therefore generally most required, when novel operations have to be entered upon.

No enterprise of this age has greater claims to novelty than that which has sought, which still seeks, to establish telegraphic communication, by a submarine cable, between the Old World and the New.

I claim, without fear of contradiction, the solution of the problem, as far as the laying of such a cable is concerned, as the birthright of the seaman; and I am now here to ask the attention, and attempt to merit the approval, of my brother seamen while I propose what I must acknowledge is a novel, and I hope they will think is a seamanlike means of performing the difficult task which I have just claimed for our profession.

Neither seamen nor fishermen will have much hesitation in granting that the best of all ways of getting a long line laid out free and clear is to run it off a reel, and our invariable practice at sea in such cases is to use reels whenever they are possible. Thus, when the question was first mooted of laying a cable, comparatively a mere thread, across the Atlantic, it is no wonder that Brunel (on being appealed to for his opinion) should have advised the use of a reel. But how to carry such a reel as would be necessary? This was held to be a fatal objection at the time, but I am now, I hope, about to show how it may be overcome. Your reel may be made in the form of a cask or cylinder, and then it will "carry itself," float, *i. e.*, with the cable reeled upon it. It will have paddle-wheels on the ends, and be set in a frame by which it may be

towed, revolving as it passes through the water. The model cylinder which you see on the two lines stretched across the platform overhead represents the form I propose. I am sorry there is here no water sufficient to float it, for seamen are generally supposed to be at their wits' end in the absence of that element; but yet, as we ought to be always ready to take a lesson from any one, I have thought I might here take a lesson from Mons. Blondin, and substitute a tightrope for the sea.* It is almost as dangerous, and therefore may in some other respects be likened to it, and it happens to answer the purpose in showing the unrolling and consequent descent of the cable moderately well.

I grant that this will have to be a big cask, but perhaps not so big or so unwieldly as would at first sight appear probable. First, what is the weight and size of the cable to be carried? I will take the late Atlantic Cable as a specimen. This weighed, in air, 1 ton per mile; in water, 14 cwt. Its diameter was $\frac{5}{8}$ths of an inch. Suppose we have to carry 1,500 miles of such a cable, and in round numbers we will say it weighs 1,500 tons (neglecting the sp. gr.). I cannot tow my reel conveniently, as I should wish, if it is more than about $\frac{4}{10}$ths immersed, so I want more than double 1,500 tons as the carrying power of the cask, cylinder, or reel. I find by calculation that a cylinder 60 feet long by 50 feet in diameter will have a tonnage of 3,386. Four-tenths of this is 1,354 tons, leaving 146 tons to make up the 1,500, which must be accounted for (if I do not desire to increase the size of the cylinder) by the different specific gravity of that portion of the cable which is immersed. This will easily be done if we consider that the gain from this cause will be equal to 406 tons, or there will be a diminution of the weight to that amount of the $\frac{4}{10}$ths of the cable which will be immersed. The diagram No. 1 shows the proportion which a cylinder bears to the ship towing it. The cylinder shown there is calculated to carry a cable which has less specific gravity, and less weight, but which is one now generally approved of, and which I have little doubt must eventually be used. It is designed and constructed by Mr. Allan, and specimens of it are upon the table. That cylinder,

No. 1.

A.—Ship 300 feet long, 50 feet beam. B.—Cylinder 50 long, 30 diameter.

therefore, has a diameter of 38 feet only, by a length of 50, which gives a tonnage of 1,628, and is fitted to carry a cable whose weight in air is 10 cwt., in water 4 cwt., and diameter $\frac{1}{2}$ inch—length now thought sufficient 1,000 miles. This for two cylinders will be 2,000 miles. The distance is 1,650 nautical miles, and this will therefore give a slack

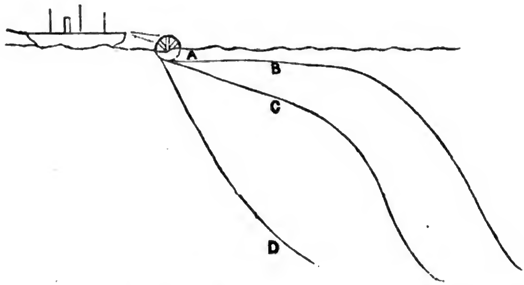
* Two lines were tightly strained across from gallery to gallery, and on these the cylinder revolved as it was drawn along, and paid off the cable below. J. H. S.

amounting to 20 per cent., which is ample. Now, as to the space occupied by the cable when reeled on. I find (referring still to the old Atlantic) that for 1,500 miles of it, $\frac{5}{8}$ths in thickness, on a cylinder whose diameter is 50 feet and length 60, there will be in the 60 feet 1,153 turns, making one fake or layer of $31\frac{8}{10}$ miles, and that of these layers there will be 48, making a total thickness of two feet six inches only.

In no other way can you stow it as neatly or in so small a space, and you can reel it on evenly and quickly by mooring the cylinder off a wharf, and either have steam-engines on the wharf to set the cylinder in rotation or use your paddle-wheels, which, as shewn in the model, are attached to the ends to do the work. As the tide or stream passed the cylinder, it is evident that it would operate on the paddle-boards and cause rotation. The principal object of the paddles is, however, not this. You will observe that they do not move independently of the cylinder, that they are, in fact, fixed to the cylinder, and its axles, as I have explained; therefore, if subjected to the action of a current of water, they would cause the rotation of the cylinder. But what will be their action while the cylinder is being towed forward by the ship? What would be the result if they were not present? The end of the cable being once let go, or allowed to sink, the whole cable would run off unchecked, and deposit itself in a coil on the bottom. But the paddles will prevent this by beating the water and causing forward movement of the whole body. It appears then that the weight of cable is as a constant clock-weight—taking the place of steam in producing motive power—and capable of relieving the ship towing, under certain circumstances, of a portion of the work. But this action, whatever its amount, is co-existent with another. Whether, in a current, the water passes by, and impinges upon, the paddles; or whether, as in towing, the body to which the paddles are attached passes through the water, the result is the same, namely, the rotation of that body. So, as the cylinder is towed forward, the cable is thrown off, with an acceleration due to the weight of the cable, and a retardation due to the diminishing diameter of the reel, as compared with that of the paddles. There is also another compensation. As the cable is thrown off the cylinder lightens, and less resistance will be opposed by the paddles to the dragging off of the cable. But coincidently, the depth of water, and therefore the weight suspended, will have diminished, and therefore the diminution of resistance is only what would have been required. The motive-power which I have spoken of as being derived from the weight of cable supended, was remarked upon immediately by a friend whose opinion I early sought on the subject, Mr. Gravatt, F.R.S., a mathematician whose name need only be mentioned to ensure respect for his dicta on such a point. Hs said as soon as he saw the model,—"Why, it will run over the ship." It was true enough, if the ship had not had steam-power sufficient to get out of the way, but on going more into the matter, we found that this would be the action. If you could only go as fast as the cable could sink, *i.e.* about two miles per hour, then the weight of cable would assist the towing. If you went faster than this, then, owing to the angle at which the cable descended being altered, growing more astern, it would not help the cylinder forward at all at a high speed,

and less as the angle with the horizon decreased. After the angle of 45° is passed (see diagram No. 2) the backward pull exceeds the forward impulse, and *vice versâ.*

No. 2.



A—Curves of cable when ship goes faster than cable can sink. **A B** increases in length if specific gravity is diminished or speed of ship increased.
C—Curve when cylinder is stopped on its way.
D—Catenary curve assumed when progress has been stopped long enough to allow cable to reach it.

Thus, I neither mean to propose to you that the cylinder should lay its own cable, nor do I fear that it should run over the ship, although these forces will be acting in the way I have described at certain times and under certain circumstances.

It is clear that, having no cable to carry in the towing-vessel, you can carry plenty of coals, and that the trim will not be subject to the tremendous variation between 1500 tons and nothing by way of cargo, independently of the coal consumption.

Here, then, is a reel which carries your cable in water, keeping it cool, which you cannot sink in a gale (for where ships founder casks often float), which does away with all danger to ship and crew, and which I think you will admit, in any moderate weather, would lay your cable as straight and free from kinks as possible.

I have not yet told you, what is nevertheless a very important point, that the weight of this cylinder would be about 260 tons, if of half-inch iron plate, inclusive of two double ends, two partitions, paddle-wheels, stays, frame, &c. &c., and that the total cost would be about £4,000, one-sixth of the value of a ship, if built to carry the same quantity of a similar cable.

The electrical communication which it is necessary or at any rate advisable to keep up during the towing of the cylinder and deposition of the cable is provided for by passing the inner end, in coiling the cable on, out through a pipe leading from the surface of the cylinder to the axle. Here it is allowed to revolve freely, dipping into a cup of mercury on the frame, or otherwise spring contact may be employed, and from this point

a short cable or gutta-percha covered wire is led along the towing-cable to the ship.

If we consider farther the action of the cylinder when towed, we shall see that, whether the cable is allowed to run off or not, the paddles will cause the cylinder to revolve directly, and in proportion as the ship towing moves ahead. There would be, I have no doubt, a considerable diminution of speed consequent on the towing so large a body while going out to the mid-Atlantic, and therefore not giving off cable. But it need scarcely be feared that the speed of such a vessel as the Terrible, which is, perhaps, the best adapted for the purpose, would be diminished to anything like half her usual rate, which is ten knots. Therefore I believe she would be able to go seven with this reel astern. A proposition has been made by some naval officers that I should add to the cylinder a false bow of iron, which might be knocked away after getting out to mid-ocean; but I am opposed to this suggestion for two reasons: First, because all unnecessary complexity is to be avoided, the most perfect machine being always the most simple that will fulfil the purpose; and, secondly, because if better water-lines and easier towing be absolutely required, the best way to get it in this instance is by increasing the size of the cylinder, and thereby making it float lighter from the beginning. However, my own impression is decidedly, that if we can do it well enough, we shall do it quickly enough. *Sat cito si sat bene* must be our motto, and if we can accomplish seven knots, or 168 miles a-day, it will, after all, only take five days to reach the mid-Atlantic, the nautical distance being half of 1650, or 825 miles only. In support of my belief that this speed would be attainable, I may mention that the Tartarus, of about 150 horse-power, towed the Caledonia three-decker at five knots, her own speed being eight, that the Napoleon towed two French line-of-battle ships with a diminution of only two knots of her usual speed; and lastly, that the friction, which it is known offers no inconsiderable part of the resistance to the passage of bodies through water, is here, to a very great extent, absent, owing to the revolution of the cylinder on its axis. Whatever may be, however, the force of the objection to be made as to the towing, it cannot equally apply during the process of laying cable. Then, not only will the cable aid the advance of the cylinder under certain circumstances, which I have already pointed out, but with every mile traversed the cylinder throws off a portion of the weight, rises out of the water, and offers a better shaped bottom for passing through the fluid. But I should deserve the name of a fair-weather seaman if I failed to notice the probable action of a gale, or a heavy sea, on this system of laying. Let us suppose, then, first, that a gale is encountered before beginning the laying, while each ship is towing her cylinder to the mid-Atlantic, or elsewhere. As for the cylinder itself, it is absolutely safe under such circumstances, as also the cable upon it, unless the ship, by lubberly management (which I can scarcely suppose to be likely), runs into it, then some damage might occur, either to the cable or the frame by which the cylinder is towed. I do not say it would be inevitable that such damage should occur, for I think that in many cases of contact between the ship and cylinder it would be pushed away without more injury than denting the frame which surrounds it, and which would be

made of hollow beams, constructed from half-inch plate iron. But this cause of danger, if it exist, is equally to be found in the system of laying from ships; indeed, such a case has already occurred in laying the Toulon and Algiers cable, where, on one occasion, the operation was suddenly stopped by a French steamer, charged to convoy her, running into the vessel carrying the cable. I will, once for all, remark that if, of two systems, the one can be shown to be safer, more expeditious, and less expensive than another, it cannot fairly be required that there should be no difficulties whatever in it, while that other is full of them. Laying cables across the ocean, whatever may be affirmed by landsmen, can never be other than a most delicate and difficult operation, requiring most scientific seamanship, calling into action all the practical resources of the sailor, combined with whatever aids science can supply.

But to return to the case of a gale occurring. You would lie to, run before it, or keep bow to sea under short steam, just as circumstances might require. If necessary, you might even let go the cylinder, taking care to adopt such precautions as not to lose sight of it, and again make fast when the weather moderated. My own opinion, however, is, that under no conceivable circumstances could such a course become necessary.

The second difficulty which may occur is, a gale during the laying. This may declare itself ahead, astern, or on either beam. If the gale be ahead a diminished rate of progression will be the result, for, if the captain knows his work, he will not attempt a high speed. "Thrashing at it" would do no good, and might do a great deal of harm. But at any rate not so much danger need be apprehended as with a ship which has the cable coiled in her hold, for several reasons. First the pitching and rolling, as you will see by the plate, are, as well as the scend, either totally absent in the cylinder or very materially modified; the rise and fall of the wave, together with its forward impulse during the short time it is passing under the cylinder, being the measure of motion imparted to the cable, which is always being steadily unrolled or paid out. There is no uncoiling in a hold or handing out packings or lashings (see Blue Book), nor any landsman superintending a brake (break?) while he himself is scarce able to stand or see, and very likely devotes one hand to his own purposes and one to the requirements of the cable, if even he is able to do that. About the orthography of this word brake (break) there is a great difference of opinion, some spelling it one way, some the other, but I am inclined to think there is great similarity in their action as applied to this purpose, for the *brake* generally breaks the cable. The most perfect brakes which I can find are the paddle wheels, for these, according to the proportion which their diameters bear to the diameter of the cylinder, will either throw off slack or apply a per-centage of strain as may be desired, the necessary alteration being accomplished by the use of very simple mechanical appliances which I will presently describe; and more, they will resist the *dragging* off of cable, never absolutely, but as the squares of the velocity with which it is sought to be done, so that any strain due to the rise and fall of a wave will be given way to; but the pulling off of cable in excess of the rate at which the ship is going through the water will be effectually resisted.

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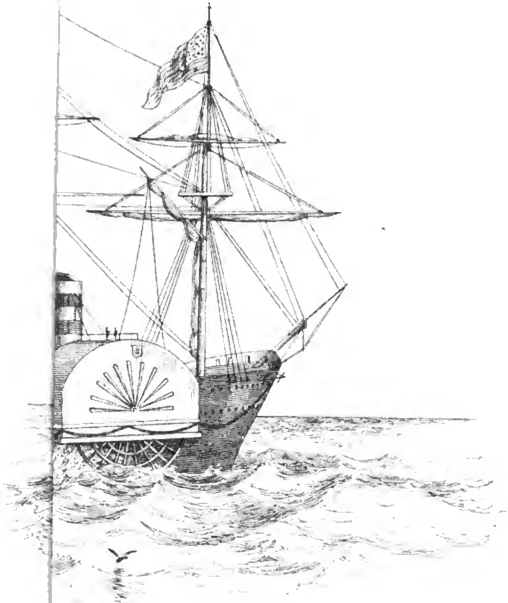
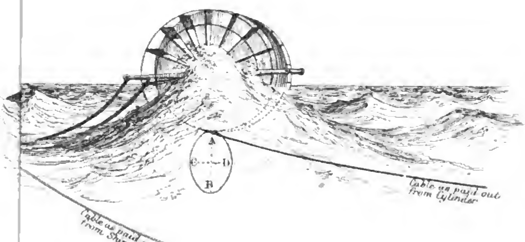


TELEGRAPH CABLES.

ged.



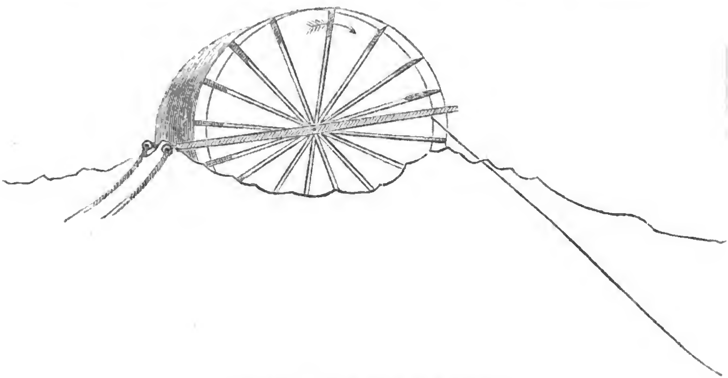
J.R.Jobbins

The appliance above referred to, and which is shown in the patent drawings,* consists of a clutch fixed on the fore part of the frame on each side at the spot where the centres of the paddle-floats pass during the revolution of the wheels. This is moveable on its axis by pulling ropes from the ship. If the one end be projected forward it will encounter the arms, which, like spokes of a wheel or capstan bars, are fixed on the heads of long screw radii, and these when moved cause the recession of the paddle floats to their common centre. If the other arm of the clutch, on the contrary, be the one projected, then the screws are turned in the opposite direction, and the floats, instead of being "reefed," are "expanded." But this apparatus has been contrived more in deference to the views of others than my own conviction. I do not anticipate, though it would undoubtedly fulfil its purpose, any necessity for its use while laying cable. To return to our gale and its difficulties. If the wind be astern, I do not know any limit to the speed with which the cable may safely be thrown off in the path of the vessel as it certainly will be by the revolution of the cylinder. If the gale be abeam, a current course will be shaped, or rather the leeway must be allowed for as usual, and no fear need be entertained that the cylinder will not "come after the ship" perfectly square, for we are not towing as ordinarily by the apex of a triangle represented thus. The base is the stern of the ship towing, the tow-ropes forming the sides, and the hawse-holes of the ship towed the apex, but in a totally different manner, the points at which the tow-ropes are attached to the cylinder being more widely separated than those which they leave at the stern of the towing vessel. In towing a ship, as described above, if there be a heavy sea, she inevitably sheers about, even when well steered, and from that cause, as also the heavy pitching, brings great strains on the tow-ropes if she do not even break them. The heavy pitching is caused by the fact, illustrated in the plate, that the wave continues to raise the stern until it reaches the centre of the ship's length, causing thereby a motion in a vertical direction much exceeding the height of the wave alone, in fact one due to a multiple of that height by the half length of the ship.

I may here mention that I propose to use as towing cables Manilla hemp combined with steel wire, which experience has shown to be the best means of obtaining great strength and great lightness. Four of these would be used, two of which as preventers; I should prefer to shackle them to chain cables on board the towing vessel, passing them out of the hawse holes, and hanging them outside the ship with proper stoppers and quarter tackles. Also at the points of strain on the cylinder and the ship I would make use of "buffer" or spiral springs to diminish any jerking action. Counters for the number of revolutions by bell signal to the ship, lights for night work, means of locking the cylinder, and either stopping or retarding its revolution, or causing it to revolve by hand, would also probably be adopted. I think most of the ordinary difficulties which can be foreseen have now been considered, but, if a breakdown of engines or other extraordinary difficulty should occur, it may be asked how we should then act? The engine stops. If you have, as you probably would have,

* The number of the Patent is 2,884.

a consort, you may, without much danger or difficulty, change places with her. There is no shifting possible if the cable is coiled on board a ship. She may, it is true, be taken in tow, but I have already shown why it is much more difficult to tow a ship than this cylinder, not as regards the rate, but the breakage of tow-ropes. But if the tow-ropes should, with the cylinder, be unfortunately carried away in fine weather, you would of course soon make fast again, while in a gale the cable will take about two hours, or perhaps more, before the curve, which I shall presently show to exist during the laying, will have sunk sufficiently to allow of a fair strain being brought upon it. Then the cylinder will of itself turn round and ride to the cable, giving off cable slowly in answer to any strain, but



Cylinder abandoned or cast off temporarily.

resisting any rapid dragging of it off by the beating of the paddles on the water, and the ship must lie by it until the gale moderates or she can in any way get it in tow, which might not be attended with any great difficulty. But here again, with proper management, I consider that this breaking adrift is an unlikely occurrence. There is no object to be gained in forcing the ship ahead in such a way as to endanger the tow-ropes. I do not believe there would be any difficulty in having a crew of ten men or so on the cylinder frame during the whole operation if it turned out to be desirable, and would cheerfully volunteer to take charge of them myself. I know that a ship in a gale of wind may founder, particularly if she has or has had telegraphic cable coiled in her holds and on her decks, and is either, therefore, over weighed or not ballasted, while I am satisfied that this structure would be almost if not quite unsinkable by anything in the shape of wind or sea. If it should even leak, which is little to be feared in such a vessel, cask, or cylinder, proved as it might be by hydrostatic pressure, then it may be made to pump itself out by very simple means whenever it is revolving, as is done every day in our sugar refineries and other works where large cylinders heated internally by

steam have hollow axles with scoops attached inside as radii. These take up the condensed water from the bottom as they pass through it and deliver it at the axle.

If it be desired to lift cable which has already been laid, this may be done by making fast to the after-part of the cylinder frame, and towing in the reverse direction. The paddles will, as before, cause revolution, and wind up the cable. Under-running may also be accomplished in the same way by taking two or three turns of the cable round the cylinder, and towing or slowly moving the cylinder in the direction which you wish to raise. For these processes, in any moderate depth of water, say three or four hundred fathoms, the cylinder would be most valuable, while even in greater depths it might sometimes be successful where any other means would fail. In fact, any cable which would bear its own weight might be thus recovered or repaired.

As the cable is by this system not exposed to any mechanical violence, as it is always in water, and may be tested in water during the whole of the reeling on, and on the outward voyage, it becomes almost certain that a mere gutta percha covered wire *could* be laid successfully. I have recommended, and I continue to advocate, the employment of internal steel wire, to give strength, but I should not consider it indispensable for laying alone if these means be employed. Yet I am no admirer of excessively light cables, which it is now the fashion to praise. Surface currents cannot be ignored, and they are greatly more to be feared, as the specific gravity of the cable is decreased, while, as we may wish to lift the cable, or some portion of it, for repair, strength is by no means to be neglected. To place steel or iron wire outside a cable, where the salt water can get at it, after whatever lapse of time, is only to insure its destruction by chlorides or oxides. It has been sought to remedy this by means which I can only compare to those adopted by an elderly lady of my acquaintance. She bought a Turkey carpet: in order that it might not be too roughly visited by the winds of heaven, or the feet of the profane, she covered it carefully with an Indian mat; but this also was too good to be ill-used, so she finally applied a brown holland over both. So it is with a telegraph cable, we first construct the two essential parts,—the conductor and its insulator—then we set to work to combat a shadow; we ignore the reduced specific gravity and treat the wire as if it alone were to be suspended in water. Under this impression we construct an outer system of wires enveloping the cable as in the arms of death. These again we are now covering with an insulating material, and it is probable that we shall perceive that the latter will also require to be protected by something else. Unfortunately in this case the brown holland is likely to be more expensive than the Turkey carpet. One electrician, whose cables are very beautiful to look at, has really put a larger copper conductor, in the shape of sheathing, outside his cable than there is inside it, and I strongly advise him to put an insulator outside that again, if he does not desire to throw away the copper or brass outside altogether. It cannot contribute to strength, for if copper could support its own weight in water it would be as well done by the small conductor inside. It professes, I know, to save the insulator from ill-treatment by cable layers or munching by molluscs, but is ill-treatment necessary, and will molluscs, where they do exist, be

more injurious to gutta percha than salt water to copper? As for *spiral* iron or steel wires outside a soft core and a straight conductor, I can find no words sufficiently strong to express my astonishment, at such a transgression of all mechanical laws, at such a self-evident fallacy. They are unprotected from rust or metallic veins on the bottom; they compress the soft core, and at the same time elongate and bring all the strain on the copper wire which they ought to sustain. They are liable to kink, and certain to decay. They present, in short, the best possible contrivance of "how not to do it." I have been told that the iron wires always broke first in the experiments, but I am sure that, had the test been applied of hanging a weight down a well by one of such cables, we should have had a very great tendency to untwist on the part of the spiral and a corresponding elongation of the copper wire. Of course the iron would, even then, break before the copper, but you would indefinitely attenuate the conductor, which, I presume, would not be considered desirable.

But with cables I have little to do. Whatever they may be, I will undertake to lay them (D. V.) in the same state in which they left the manufacturer's hands; and more no telegraphist can expect from seamen.

I would by no means be understood to say that a cylinder should be built, and sent at once to the work of laying an Atlantic cable, without trial. There can be no reason why full and satisfactory experiments should not be made previously; but if, as I hope, the opinions of many able men whom I have consulted already, as well in the naval as in other professions, and who are nearly unanimous in their belief in the feasibility of the plan—if these opinions are still farther confirmed by the verdict of this Institution; then surely it is worth while, by the expenditure of a few thousands, to try whether a stop may not be put to those failures which have already swallowed up a million and a half sterling, and so shaken public faith in telegraphic submarine communication that no proposition which involves a recurrence to the old method of coiling in ships will ever be listened to with favour by the Government or the nation. I mentioned the expenditure, but I am prepared to show that other uses could be profitably found for such a vessel as I propose, even if it did not fulfil the sanguine expectation which my friends and I entertain of success in laying cables by its means; for the necessity of storing submarine cables after manufacture in water has led, in some instances, to the construction of tanks on purpose. Even there, the water has to be changed and, if possible, kept cool by pumping. But such a cylinder as this would, if left moored in a tideway, keep rotating, and the cable would be perfectly safe on it, whether as regards mechanical violence or raised temperature. If, in spite of every care, the testing should show a fault while laying, supposing the faulty part to have been paid-out, it would be possible to reel it up again, either by towing in the opposite direction, or by a hand-motion given to the cylinder from the frame. If the fault were discovered while still on the cylinder, as there are about thirty-one miles in each layer, the operation of laying may be stopped, and the fault be cut out whenever necessary. But faults can scarcely be expected to occur, when a cable is treated as it would be on this principle. They are more likely to exist, or be caused, where the cable, in a hold and during its coiling into it, has to be subjected to a handling which, even where every care is taken,

is too likely to be attended with accident, and which gives opportunities for wilful damage, and which have not always been passed over without harm. Here, on the contrary, nothing but water ever touches the cable after or during the coiling-on—the very coiling is, to speak correctly, now changed to a winding or reeling on, which is far less likely to injure the cable, and the difference of which any seaman will readily understand. A similar motion in unwinding or paying-out will do away with all necessity for brakes, and most of the causes of breakage.

I have now, I venture to hope, sufficiently explained a system of laying and generally treating submarine telegraph cables, which at least cannot be said to be objectionably complex; and I hope that a free discussion of its demerits or otherwise may bring out all those "No's" which are much more valuable to every inventor than any number of "Yes's."

Here, as at the Naval Architects' Institution, where I have recently been kindly permitted to read a paper on the same subject, I am fully conscious of the great competency of my hearers to judge the merits of the system; and, therefore, whilst thanking the members of the Royal United Service Institution most warmly for their goodness in allowing me thus to bring the matter before them, I have only to beg for an impartial consideration of the subject, and that I may have the opportunity of answering, if that be possible, any objections which may suggest themselves now or hereafter.

One word more and I have done. There may be objections to be made, and minor difficulties to be overcome in this as in every other novelty; but there is nothing that a seaman need fear.

On the other hand, I fearlessly maintain that, unless by a miracle, no cable could ever be successfully laid over such a stretch as the Atlantic by coiling it into a hold at the commencement; and more, that, whatever may be said, no cable has ever yet been laid, either by Messrs. Glass, Elliott, or others, which approaches such conditions as are here to be met. The Toulon and Algiers cable was only laid in pieces, so to speak. The first attempt took them nowhere; the second, as far as Minorca; and the third, from Minorca to Toulon. Is this such a success as ought to be or can be referred to, as promising another, in laying a cable across the Atlantic? Is the Red Sea a success? Is the Alexandria and Malta, laid in a continuous length across deep water? Ill-treated as it had been in a hold, they even now fear to work through it at the speed they would otherwise do.

No; if not this plan, then some better one—but let it at least be one which seamen can approve, not a clumsy attempt to overlay landsmen's difficulties with landsmen's expedients, which are discovered successively, after the cable is broken, to have been mistakes. I can compare the proceedings hitherto to nothing so well as the attempts at pulling (rowing, landsmen call it) of a greenhorn in a boat. He seizes an oar—possibly even adventures on the stroke oar, if he is not speedily ejected. Then his miseries begin—perhaps he catches a crab—probably he breaks his oar—and it is always the fault of somebody or something, not himself, that he does not succeed: at length some old seaman, pitying his troubles, "double banks" his oar, and teaches him practically the value of that turn of the wrist, which seems easy enough to look at, but nevertheless takes some time to attain.

Seamen, as a body, are generally very ready to communicate their knowledge to those who come among them from the land, more so than most professions or trades, but neither their goodwill, nor even the undoubted aptness and acquisitive talent of telegraphic engineers, can make it possible to compress the learning of years into the compass of a voyage or two, lasting each a fortnight or so. Such a space of time is barely sufficient to overcome the rebellion of the stomach, or to master the mysteries of the soup plate. A very clever fellow perhaps learns, in addition, not to hold on to a slack rope, nor to seek the weather gangway on dire occasions; but the greatest progress which can be expected is, after all, as in the case before us, that the tyro should have learnt how he can *not* do it, and be willing to confess that, after all, it is a nautical question how to carry out great operations at sea, which can only receive its proper solution from seamen.

To them, therefore, as represented by this Institution I turn for approval; and if they do sanction my labours, I have no doubt that the telegraphists will join us heart and hand in carrying to a really successful issue this magnificent work, which I firmly believe is yet destined to play its part, under Divine Providence, in the spread of that universal peace—of that knowledge of Him which shall one day "cover the earth as the waters cover the sea."

Friday, May 16th, 1862.

MAJOR-GENERAL THE HONOURABLE J. LINDSAY, M.P., in the Chair.

MILITARY TRAINING,

CONSIDERED PRINCIPALLY WITH REFERENCE TO THE MOST ADVANTAGEOUS ARRANGEMENT OF THE EXERCISES AND OCCUPATIONS OF INFANTRY SOLDIERS.

(*Being a Sequel to Lecture delivered on the 8th of March,* 1861, *on Military Training, considered principally with reference to the Measures adapted for the Development of Individual Excellence.*)

By LIEUTENANT-COLONEL A. CUNNINGHAM ROBERTSON,
1st Batt. 8th (The King's) Regiment.

In a Lecture which I had last year the honour of delivering in this place I enumerated ten different kinds of instruction which it appeared to me desirable that our infantry soldiers should receive, namely, instruction—

I. Individual Instruction.

1. In marching and setting-up drill.
2. In gymnastic exercises.
3. In the use of arms and intrenching tools.
4. In field cookery.

II. Collective Instruction.

5. In field exercises and evolutions.
6. In heavy gun drill and the management of artillery.
7. In the method of constructing trenches and batteries in the presence of an enemy.
8. In escalading.
9. In the method of pitching tents and of constructing huts.
10. In the method of using tackles, and in the modes of applying some of the simpler mechanical contrivances for moving heavy bodies.

I do not think it necessary to say a single word in order to prove that if it were possible it would be very desirable that all the different kinds of instruction I have enumerated should be given to our infantry soldiers; but whether or not that which is undeniably desirable can be proved to be practicable is a question which cannot be determined without careful investigation.

What I shall now attempt to do is to state to you as fully as possible my reasons for thinking, that, after making due allowance for interruptions occasioned by bad weather, sickness, and duties, and after also allowing ample time for repose and for keeping in order arms, accoutrements, clothing, and quarters, the remaining time available for the instruction of the

soldier is sufficient for the acquisition and practice of all the arts and exercises in which it is desirable that infantry soldiers should be proficient.

The three great branches of the training of an infantry soldier are,—

1st. Field exercises and evolutions.

2nd. Rifle shooting.

3rd. Gymnastic exercises.

In order to determine how much time must be devoted to these three branches, and how much will be available for other arts and exercises, we must consider what is the precise object of each kind of training, and the nature and amount of instruction necessary to enable a recruit to do the particular thing required with ease and accuracy.

Commencing with field exercises—the object of this branch of training is to enable the officer who commands a body of troops to form the line of battle in the most expeditious manner in any given direction, and to execute without confusion such changes of position or formation as may be expedient, either for the purposes of attack or defence. In order to enable an officer to guide the motions of a body of troops, each individual soldier must know the method of performing a variety of evolutions, and when particular commands are given must be accustomed to act in a certain prescribed way. Very different estimates will be formed by different individuals of the nature of the instruction and of the time required to teach the recruit to do this. If, in order to form the line of battle without confusion and with the utmost possible rapidity, it be necessary that soldiers should be trained to absolute precision of movement, if it be necessary that the length of pace and rate of movement of every individual soldier should be precisely the same; if this be necessary, then experience proves that such perfection of movement can only be acquired after a long course of most assiduous training, and that it cannot be kept up without constant and laborious practice; so constant and laborious that troops accustomed to move on parade and to handle their arms with perfect precision will have little time for any other occupation than the life-long, daily monotonous routine of squad, company, and battalion drill.

If, on the other hand, this absolute precision of movement be not essential; if it be found that in practice considerable looseness and irregularity of movement has no tendency to create confusion, and is perfectly compatible with the utmost rapidity and most perfect accuracy of formation; if it be found that this absolute precision of movement, which is so imposing and admirable on the parade ground, is by no means essential to efficiency in the field, then it is obvious that the process of teaching troops field exercises and evolutions will be completely divested of its laborious character; that after recruits have been drilled to act together, and have been taught the few and simple methods by which all possible changes of position and all useful changes of formation may be effected, comparatively speaking, very little time need be devoted to the practice of these methods.

It appears to me that to train soldiers on a system which aims at absolute mathematical precision of movement, so far from being necessary or even advantageous, is in its tendency absolutely injurious to their efficiency in the field.

In order to understand how it is that an apparent perfection is in reality an imperfection, let it be remembered that the conditions of warfare do not admit of the preservation of perfect, unbroken order in the formation of troops, nor of perfect mathematical precision in their movements. Now, if troops throughout the whole course of their training have been taught to believe that perfect regularity in their formations and perfect precision in their movements are essential to their efficiency, these troops, when for the first time they are placed in circumstances where a certain degree of derangement in their formations and of looseness of movement are unavoidable, are apt to imagine that such deviations from the precision of parade are evidences of mismanagement and failure. The more perfect the parade training of the troops the greater influence has the idea of their incapacity for acting together with effect under conditions which their parade training has never attempted to imitate. Commands which they cannot execute with their accustomed precision they scarcely attempt to execute at all. It is very possible that a highly-drilled battalion, which years of assiduous training in the art of parade evolutions had rendered the model for an army, might, when brought for the first time into contact with an enemy, be found more unmanageable and unhandy than an undrilled guerilla levy which had received no other training than such practical lessons in the art of united action as it might have picked up during a few months of warfare.

Of course a very little experience of campaigning teaches the regular as well as the irregular soldier that unity of action is perfectly compatible with broken ranks and with very considerable looseness of movement, but I myself have had more than one opportunity of observing that this is not one of the lessons which either officers or soldiers learn on the parade ground, and I should think that almost every officer who has seen troops led into action for the first time must be able to recall to his memory incidents which would serve to illustrate and confirm the observations which have just been made.

If, therefore, the method of executing battalion movements on parade was so modified as to be made to resemble as nearly as possible the manner in which the usual conditions of warfare render it unavoidable that these movements must be executed in the field, it appears to me that these modifications would not only render this part of a soldier's training simpler and more easily taught, but that it would also render it much more practical and serviceable.

Without attempting to go into the details of such modifications as might be suggested for carrying out this view, I shall merely, for the sake of illustration, indicate some of the expedients which might be made use of in order to accustom soldiers on parade to those irregularities and deviations from uniformity which must inevitably occur during field service, and in order to facilitate the management of troops when they are required to move loosely and with the order of their formation more or less deranged.

I. Companies should never be equalised when practising battalion movements.

In deployments, formations of columns, and echellon movements it

makes no practical difference in the mode of executing these movements whether companies be equal or unequal, but in symmetrical manœuvres, such as double-column movements and the formation of squares, when the companies are of unequal strength these evolutions cannot be executed with the same precision as when companies have been equalised. It seems particularly desirable that the formation of squares should always be practised with companies of unequal strength; because when squares are required to be formed in the field the troops have generally been some time under fire, many casualties have occurred, and the manœuvre has to be executed under conditions which render the symmetrical formations of the parade ground quite impossible.

II. Battalions should be practised in executing changes of front and other manœuvres by the successive as well as the simultaneous movements of companies, no general word of command being given, but the necessary caution being passed from company to company.

The manner of passing a command along a line, or from front to rear of a column, is a matter of considerable practical importance, it is a process which should be performed in a systematic manner and which should be frequently practised.

III.—In order to accustom troops to move loosely, battalions should be practised in deploying, with intervals between the companies equal to about a quarter of their front. The line should then be ordered to advance, the men of each company opening out on the march so as to fill up the intervals: at the word "halt" the men should instantly close on their right files. A loose movement should always be followed by a perfectly accurate formation. The instant a line halts, without further caution the coverers should move out four paces; they should then face to the right or left as might be ordered, and as soon as accurately covered the companies should move up in succession and dress. If the companies are ordered to commence firing immediately on entering the alignment, the coverers should move out the instant the "cease firing" sounds.

IV. The captain of a company ought to be required to exercise an efficient control and superintendence over the movements of his company; he ought to be required to correct the errors of his men, to check or accelerate their pace, to break off files, and to make such other changes in the order of their formation as may be necessary for the purpose of passing obstacles, to repeat words of command, and to see that they are properly obeyed.

To enable him to do these things he must be relieved from the duty of preserving covering and distance in column, and both in line and column permitted to use his own discretion in changing his place and going to whatever point may appear to him most convenient for superintending and directing the movements of his men. I believe when the drill-book was last revised Colonel Lysons was strongly urged by many officers to introduce the change suggested in the parade functions of captains of companies, but unfortunately could not be persuaded to do so.

When a strong battalion is moving over broken ground it is impossible for a commanding officer to keep the men properly in hand or to exercise an effective control over their movements without the active assistance of

captains of companies, and that assistance they cannot possibly render if they remain in the position and perform the duties assigned them by the present regulations.

To preserve covering and distance and to precede and guide a company should be the function of a serjeant told off for that especial duty. Each of these company guides should carry a small distinguishing flag, differing in form or colour from those of the other companies. These distinguishing pennons would be very useful as rallying points. In moving loosely in line over broken ground the guides should precede the line by two or three paces; and, however loosely and independently the men might be moving, they should be so trained that every individual soldier should carefully avoid getting in advance of the line of guides, and that all should look to these men for the regulation both of the pace and of the general direction of the movement.

Divisional field days on broken ground, such as the ground on which the Aldershot division exercises, are no doubt highly instructive to officers, but I am doubtful whether the private soldier, trained according to existing methods, can derive any benefit from them. The contrast between the loose movements, the disordered ranks, and the many irregularities of the divisional exercises, and the perfect precision of the drill on his own regimental parade, is so violent that he must either conclude that the looseness and irregularities of the divisional practice are the result of bungling, or else that the precision of his regimental training is utterly useless and absurd. I believe the former opinion is that to which the soldier usually inclines. He is apt to consider every deviation from the precision and regularity of a barrack square drill as a sign of failure and mismanagement. The impression made on his mind of what he has witnessed or performed during a scramble to the top of Cæsar's camp very often is, that his commanding officer or his general has made a mess of the business; and not unfrequently this opinion is partly consistent with fact, for when the natural difficulties of ground have deranged the formation of the troops, and made looseness of movement unavoidable, officers and men being alike destitute of any systematic training in the best method of preserving unity of action under these conditions, the men are often very clumsily handled, and even under the most skilful management are very difficult to keep together and to preserve from getting into confusion, which, let it be remembered, is a very different thing from looseness of movement or from the derangement of the regularity of a formation.

In order to make the Aldershot field days as useful to the private soldier as to the officer, the preliminary training which the soldier receives when a recruit ought to be arranged with reference to the circumstances in which he will be placed in the future field day. What recruits are at present taught is the art of moving on smooth ground, at a measured pace, without deranging the order of their primary formation; what they ought to be taught is how to move rapidly over any kind of ground, and, however much their formation may be deranged, to execute any manœuvres that may be required without confusion, being at all times prepared to close their files and form with accurately dressed ranks on any

given alignment. This is the way in which French troops manœuvre, as is noticed in the report of a professional visit to the continent by three artillery officers in August and September, 1861. They say:

> The French appear to attach no importance to that precise and correct execution of a movement which we insist upon in our armies.
>
> Squareness of movement is almost entirely unknown among them, and individuals as well as masses almost invariably move from point to point by the shortest and most expeditious modes.

In the depôt battalions of regiments of the line the recruit is drilled three times a day, the length of each drill being from an hour to an hour and a half; about two hundred of these drills are considered necessary before the recruit is fit to take his place in the ranks and to perform his share of guards and duties.

Three drills a day in summer and two in winter is the time which the instructed soldier is required to devote to the practice of field exercises in most regiments of the line. This amount of drill is not more than enough to ensure that precision of movement which is expected of a crack regiment on parade. But, if it be considered useless to require on parade a degree of precision which it is impossible to preserve in the field, a much smaller number of drills would suffice. Three drills a day for two months in the spring, one drill a day during the rest of the year, and one brigade field-day a week during the summer, would be amply sufficient to keep troops thoroughly efficient in their field exercises.

At Chatham, the recruits of the Royal Engineers receive pretty nearly the same amount of instruction in field exercises as recruits of the Line; but, after going through this course, one drill a week is found sufficient for practical purposes.

Volunteers can only be got together for drill purposes at irregular intervals, seldom so frequently as once a week; yet this scanty and irregular training, which includes both original instruction and subsequent practice, suffices to render a Volunteer battalion, when properly commanded, perfectly manageable and able to perform any required evolutions, not indeed with the same precision as it would be performed by a battalion of the Line on parade, but in precisely the same manner as a Line battalion would perform it on broken ground under the fire of the enemy.

When a battalion of the Line has been employed for two or three years on active service, during which parades for drill must often be suspended for long periods of time, it must be broken up into squads and thoroughly redrilled before the men are able to move on parade with the same steadiness and precision as they were accustomed to move before they took the field. Yet no one supposes that for practical purposes a battalion at the end of two or three campaigns is less efficient, less manageable, and less easily handled than before these campaigns commenced.

The next great branch of the infantry soldier's training is instruction in the use of his rifle.

The object of rifle instruction is, first, to teach the soldier to judge correctly the distance of a man placed at any point within a range of 900 yards; secondly, to teach him to hit any object fired at within that range.

The time allotted to this important branch of training is sixteen days

for the instruction of the recruit, and twelve days for the annual practice of the trained soldier, to which must be added, after the annual course is completed, one or two days a month judging distance-practice, and perhaps an equal number of days devoted to position-drill.

In order to exhibit the degree of proficiency which is attainable by this very limited amount of instruction, I requested Mr. Clarke, the schoolmaster of the 2nd battalion 8th (the King's) Regiment, to prepare from General Hay's Reports for the Years 1858-59-60 and 61 the annexed statement (*see next page*), showing the general results of the target practice of these four years.

From this statement it appears that there has been a pretty uniform improvement in the average figure of merit, which has risen from 28·31 in 1858 to 33·96 in 1861, being an increase of 5·65 in the four years, or rather less than a point and a half per annum.

But in the year 1860 the per-centage of marksmen and also of first-class shots is very much smaller than in any of the other years. It would be interesting to know if General Hay could assign any reason why these per-centages are lower while the figure of merit is higher than those of the preceding years.

If the returns of the year 1861 were accepted as a true measure of the maximum average results attainable by our present system of musketry instruction, it would follow that in every company we might reckon upon producing six marksmen, twenty first-class and fifty-three second-class shots; the average figure of merit of each instructed soldier, that is the number of points made in firing fifty shots at distances varying from 150 to 400 yards, being 33·96. These are the average results of the year's practice; but in a very considerable number of corps results were obtained which seem to indicate that in future years, when the system becomes better understood and more zealously worked, a very great improvement in this average may be expected.*

In thirty-two different corps the number of marksmen exceeded ten in a hundred; and in ten different corps between sixty-two and thirty-one men in every hundred were first-class shots. In the same ten corps the average figure of merit varied from fifty-one to forty-five points, that is to say, the ratio of points made to shots fired between 150 and 400 yards varied from 102 to 90 per cent.

Suppose such an improvement were to take place in the method of conducting our rifle instruction that the average shooting of every corps in the army became equal to the average of these ten corps, what an immense increase in the efficiency and destructive power of our infantry would this improved average represent!

I do not, indeed, put any faith in these calculations, which, from the data of the points made at target practice, deduce the exact number of men

* The publication of General Hay's report enables me to say that these anticipations of improvement have been fully realized by the progress made during the season 1861-2. Compared with the preceding year the number of marksmen has increased more than two and a third, and the number of first-class shots nearly five per cent., the number of third-class shots has decreased six per cent., the average figure of merit has risen nearly five and three-quarter points, and the number of corps in which the men classed as marksmen exceed ten per cent. of the strength has nearly doubled.

that an enemy will lose in passing over a given space at a given rate. But although we are not able at present, and perhaps never shall be able, to express in figures with mathematical exactness the precise relation that exists between skill at target practice and efficiency in the field, yet we may feel positively certain that a real relation does exist between skill and efficiency. We may feel most certainly assured that under all possible conditions (excepting, perhaps, rapid firing at close order and at short distances) the fire of a given number of marksmen will be more efficient than the fire of the same number of third-class shots. More than this, we may, I think, safely assume that when troops fire under cover at an exposed enemy the measure of the difference of efficiency of soldiers of different classes will be very nearly the same as the measure of the difference of their skill at target practice.

The following extract from a leading article of the "Times" indicates the nature of the relation existing between skill acquired at target practice and efficiency in the field, with that admirable force and perspicuity which, whatever may be the subject treated, is the invariable characteristic of any statement, whether of fact or of opinion, submitted to the

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RETURN, showing the General Results of Musketry

DATE.	Total Number of					Per Centage of			
	Men instructed	Marksmen	Men in 1st Class	Men in 2nd Class	Men in 3rd Class	Marksmen	1st Class	2nd Class	3rd Class
1857—58	42·029	...	9·819	20·620	11·590	...	23·36	49·06	27·58
1858—59	69·632	31·37	19·566	33·450	16·666	4·50	28·09	47·97	23·94
1859—60	109·321	36·36	16·488	56·623	36·210	3·33	15·08	51·79	33·12
1860—61	124·588	72·45	25·666	66·852	32·070	5·81	20·60	53·65	25·74
1861—62	131·214	10·719	35·521	69·811	25·882	8·17	25·55	53·20	19·72

Note.—Since this Lecture was delivered, General Hay's Report for the Season 1861-62 has been published. This Report, for the first time, contains tables showing the general results of the practice of the season. These valuable and interesting tables will be found at pages 11—43 and 51 of the Report, and it is possible that the idea of compiling them may have been suggested by Mr. Clark's table, which was communicated by me to the Army and Navy Gazette, and published in it in December, 1860.

General Hay has very properly limited his abstract of results to the practice of the infantry. But as the practice of the cavalry and artillery was included in the table compiled for me by Mr. Clark, I have (for the sake of enabling an exact comparison to be made with

public by the editors of the leading journal. In the article from which I quote, it is said—

Nobody expects that every shot fired by every marksman will always go as true as the shot fired at a target in a competition for prizes. But even imperfect results have their value. The object of proficiency in rifle shooting, as in all other pursuits, is to secure the highest possible average in common practice.

The First Battalion 22nd Foot enjoys, we learn, the distinction of being the best shooting battalion in the whole army. It is not in the least degree probable that in actual service the figure of merit of this regiment would be what it is in practice at home, but we should, nevertheless, feel very certain that the rifles of this regiment would, under equal conditions, do more execution than the rifles of any other regiment.

The only way, in short, of securing good average proficiency is to practice for peculiar excellence. The practical results will, of course, fall short of the specimen exhibitions, but its value will be in a direct ratio to the proficiency so acquired. The nearer our troops are brought, as a body, to the class of first-rate shots by practice at home, the more formidable will they be as a body against any enemy in the field. It may be quite true that in the heat of action a soldier will not think of recurring to any of the little distinctions he has learned on parade, but it is equally true that the training he has received will produce its effects, although it may be mechanically, and that his firing will be infinitely more effective than that of a man who has had no training at all.

INSTRUCTION FOR THE YEARS 1858-59-60-61 and 62. (*Referred to in page* 503.)

Figure of Merit			Number of Men recommended for Rewards.	Amount distributed in Musketry Premiums						Number in excess of Authorised Numbers.	No. of Corps in which Number of Marksmen exceeded 10 per cent. of number who fired.
				Total Sum			Average for each Man Instructed				
Highest	Lowest	Average		£	s.	d.	£	s.	d.		
39·08	14·59	28·31									
41·84	15·08	30·37	27·41	5,263	12	1	0	1	6¼	128	17
45·95	12·07	31·51	32·00	6,348	19	0	0	1	2	122	6
51·66	16·93	33·96	59·67	15,287	8	4	0	2	5½	956	32
54·40	26·08	39·69	84·05	15,199	4	2	0	2	3·8	1,827	59

the results of the practice of former years) included cavalry and engineers in the Abstract of the Practice of 1861-62 which I have added to Mr. Clark's table. This has the effect of somewhat lowering the per-centage of the marksmen and first and second-class shots, and of increasing the percentage of third-class shots, given at page 11 of the Report. Excluding cavalry and engineers the number of infantry instructed was 121,423

And the per-centages were, Marksmen . .	9
1st Class	27
2nd Class	55
3rd Class	18

If this be a correct representation of the nature of the connection subsisting between the proficiency of troops in their rifle training and their efficiency in the field, it becomes an important question whether or not it would not be advantageous to devote more of the soldier's time to rifle practice.

It may, I think, be assumed as certain that increased efficiency would be the result of every additional hour and of every additional round devoted to rifle practice; but the limited extent of ranges, and the expense which would attend a large increase in the expenditure of practice ammunition, are practical difficulties which would oppose any attempt to improve the efficiency of our training by increasing the number of days devoted to it. I cannot, however, help thinking that, instead of concentrating within twelve days or a fortnight the whole amount of each man's annual practice, it would be advantageous to spread it over the whole of the drill season, and to make arrangements that every soldier in the Army for thirty weeks in the year should fire three rounds a week. Arrangements might also, I think, be made for allowing marksmen to perfect themselves in the use of the rifle, by allowing them to draw as much ammunition as they choose to expend in voluntary extra practice.

Even without increasing the amount of the soldier's training, it is probable that a great deal might be done by using additional means to stimulate him to use every exertion to make the most of his opportunities. Every possible means should be used to make the attainment of excellence in rifle shooting the great object of his ambition. In my former lecture I pointed out, as a means for attaining this end, the great importance of ensuring to every man, who reaches that degree of efficiency which constitutes the qualification to be classed as a marksman, the right to wear the badge and draw the extra penny, which right, according to existing regulations, is in each particular corps limited to 10 per cent. of the strength of that corps. The great importance of this change cannot be too frequently or too strongly insisted on. As the general proficiency of the troops increases so does the number of individuals increase whose interests are affected, and whose zeal is damped by the operation of this most impolitic rule.

In the years 1859-60 and 1861 the proportion of marksmen to the number instructed, and the number of men ineligible for rewards in consequence of the per-centage of marksmen in the particular corps they belonged to exceeding the prescribed limit, was—

Years.		Per-centage of Marksmen.		Number Ineligible.
1859	..	4·50	..	128
1860	..	3·33	..	122
1861	..	5·81	.	966

Out of 124,588 men instructed in 1861, although only 5,967 on 4.79 per cent. received rewards, yet 956 marksmen were returned ineligible because in excess of 10 per cent. That is, out of every seven men qualified one was disappointed of his reward.*

* In 1862 the number of men recommended for rewards is less than six and a half per cent. of the number instructed, and, out of every forty-seven men qualified, ten were disappointed of their rewards, because they happened to belong to corps in which the number of marksmen exceeded ten per cent. of the strength.

There is another slight alteration in existing arrangements which would, I think, have a very considerable effect in increasing the interest felt by the soldier in musketry instruction. Instead of determining the best shot of the battalion simply by reference to the practice returns, I think that the two best shots of each company should be selected, and the best shot of the battalion determined by a special match between these twenty men. Every shot fired in this match should be marked in a diagram, a copy of which, neatly mounted and varnished, should be hung up over the bed of the winner. If the best shots of battalions could be pitted against one another at divisional and national matches, of course the interest would be intensified in the same degree that the sphere of competition was enlarged, and the celebrity acquired by success more widely extended.

I now proceed to offer some observations on gymnastic exercises, the third great branch of military training.

Gymnastic exercises are not practised for the same reason that we practise firing at a target with a rifle. Skill in the use of the rifle is most valuable to a soldier, it adds greatly to his efficiency, and it is solely because we desire our soldiers to acquire this skill that we cause them to practice rifle shooting. This is our sole motive, we do not look for any indirect and ulterior advantage.

But, excepting on special occasions (such as an escalade), the power to vault over a bar, to climb a pole, or to perform any of the exercises practised in the gymnasium, is not likely to be of much practical value to a soldier. It is not, therefore, solely, or even chiefly, for the sake of teaching the soldier to do these particular things that a large portion of his time ought to be devoted to gymnastic training, but chiefly because this training is the best means of developing the power of his muscles, of giving strength and suppleness to his limbs, and of increasing the force and agility of his movements. The immediate object of gymnastic training is not therefore to teach certain specific exercises, but to increase the general energy of the bodily powers, and to communicate perfect facility in all possible modes of exerting these powers.

The increased efficiency for military purposes which results from the accomplishment of this object is obvious. The same reasons which, in the selection of recruits, make us anxious to obtain the strongest limbed and best proportioned men we can find should, after a man is enlisted, make us equally anxious to use every possible means to increase and develope his strength.

The majority of infantry soldiers are by no means picked men; very many of them have been brought up in towns, under conditions not at all favourable to health. Such men are much inferior in physical power to the generality of men belonging to our agricultural population. Moreover, the routine duties and ordinary mode of life of soldiers are unfavourable to the development of muscular power. It is only by the assiduous practice of gymnastic exercises that soldiers can acquire that bodily vigour which sailors and agricultural labourers, and several descriptions of artizans acquire by the exercise of their daily occupations. A man thoroughly trained in the exercises of the gymnasium not only developes his muscular powers to the utmost extent permitted by his organisation, but he acquires perfect facility in applying his strength in

the most advantageous manner to whatever purpose it may be his object to effect; and this facility in a personal struggle will generally enable him to obtain the advantage over an untrained adversary very much his superior in bodily strength.

The increased power of endurance and capacity of exertion which are the results of gymnastic training are not, however, the only nor even the chief advantages to be derived from it; of far more consequence than these physical results are the moral effects produced by the consciousness of the new capabilities, and of the increase of power that has been acquired. The consciousness felt by the soldier that he is now able to do many things which a short time before he was unable to do; that in agility and force he now feels himself superior to many persons to whom he formerly felt himself inferior. The consciousness that this superiority is due to his having had the advantage of a special military training, the want of which renders the civilian inferior to the soldier. From this consciousness of superiority and conviction of the possession of special advantages directly originate those feelings of confidence and self-reliance which are the mainspring of daring deeds.

According to our present system of training, the only special advantages possessed by the soldier are his arms and his discipline. Deprived of these the majority of infantry soldiers possess no natural advantages; no special training on which to ground feelings of confidence and self-reliance. They are not picked men. Their ordinary occupations and exercises are not favourable to the development of bodily vigour. In guerilla warfare with a hostile rural population, and in wars carried on with savage or with half civilised tribes, the soldier generally feels that in a personal conflict he is no match for his adversaries. As long as the force of which he forms part can maintain the ranks unbroken he looks upon such adversaries as despicable, and confronts them with full confidence of success. But very different are his feelings if—surprised by some sudden onset—his ranks are broken, and he finds himself obliged to struggle single-handed with a foe superior to him in strength and agility. From such encounters the regular soldier instinctively shrinks ; physically he is over matched ; morally he is destitute of those feelings of confidence and self-reliance which are even more essential to success than superior physical strength.

In modern warfare, carried on by the regular armies of European nations, we have, until very recently, had no means of judging of the influence of gymnastic training in generating self-confidence and stimulating to daring deeds. But the signal services rendered by the French Zouaves, and the great reputation acquired in the Crimean and Italian campaigns by these and other specially trained soldiers, seem to prove that gymnastic exercises are the most important part of a soldier's training, and that proficiency in these exercises is more important than precision in drill, more important than even skill in rifle shooting.

Such is the testimony as to the estimation in which gymnastic training is now held in France, recorded by Lieut. Steinmetz in the interesting paper contributed by him to the Journal* of the Institution. He says :—

* Vol. v. p. 381.

The admirable precision sometimes exhibited in some crack regiments will be as nothing in the field of battle compared with the training which will keep soldiers always in condition, and give them not only a ready and constructive use of their intelligence, but also the utmost nimbleness of motion and hardihood of which they are capable.

The Report recording the information concerning the state of the principal continental armies collected by the three artillery officers who visited the continent in September, 1860, confirms the testimony borne by Lieut. Steinmetz as to the great importance now attached to gymnastic training, not only by the French but by the Russians.

The Report says:—

In every country great attention is paid to the setting up and physical improvement of the soldier. Nor do these exercises cease on the recruit becoming a duty man, but continue to be regarded as a part of his drill, and practised throughout his service. In Russia this is more especially the case, the other drills being constantly and pleasantly varied by gymnastics.

Gymnasiums are attached to every regiment, and although no prizes are given, or means taken to reward proficiency, yet the men are very fond of their exercises, and a spirit of emulation appears to exist among them, which must greatly facilitate the task of the instructor.

The Report contains an account of a review at Warsaw which is particularly interesting.

A high wooden castle front with three tall towers rising from it, and obstacles disposed in front, was assaulted by three columns of soldiers dressed in white canvas frocks, and carrying their arms and accoutrements.

The obstacles passed by the right column were—

1st. A deep ditch.

2nd. A high slippery slope of plank inclined at an angle of about 45° with a 10-foot perpendicular drop from the summit.

3rd. A parapet and ditch.

4th. Another ditch with palisades.

5th. A glacis with a deep ditch 18 feet broad, and row of palisades down the centre.

Obstacles of equal difficulty were passed by the other two columns, the soldiers displaying a remarkable amount of agility and readiness in surmounting them.

The moral influence exerted by the development of the bodily powers appears to have forcibly impressed a Prussian officer, whose description of a French chasseur is quoted by Lieut. Steinmetz. He says,—

As they flit about with astonishing rapidity, you recognise their enterprising spirit, their daring pluck, their quick intellect, their indefatigable endurance.

If these representations of the value of gymnastic training be accepted as correct, then the necessity imposed on us to secure to our soldiers the same advantages as are possessed by the French and other nations who have introduced this training into their military system is not less imperative than the necessity which has compelled us to follow the example of the French in protecting our ships of war with iron plates.

Inferiority of training will compromise the safety of any army, not less

inevitably than inferiority of materials will compromise the safety of a fleet.

Gymnastic training possesses the peculiar advantage of being not only exceedingly useful, but also exceedingly interesting and attractive. It is notorious that the stiff monotonous exercises of the parade ground are intolerably irksome to those who practise them, and although that part of rifle instruction which consists of target practice is interesting and exciting, yet this is preceded by a tedious drudgery of position drill, which is so tiresome and uninteresting that it has a strong tendency to render the whole process of instruction disgusting and unpopular.

Among the young and the healthy, with the exception of a few men of unusually sluggish and apathetic disposition, gymnastic exercises are invariably popular. There is no preliminary drudgery to be gone through. The first exercises of the novice are as interesting as the exercises of those in the most advanced stages of training. Both in its earliest and in its most advanced stages, the training process consists of efforts requiring the most energetic exertions, which, after being persevered in for a greater or less number of times, are certainly followed by successes producing a most delightful and animating effect on the spirits.

This is precisely the kind of occupation adapted to gratify that instinctive impulse which renders every species of activity pleasing to the young. Practised alone by a single individual, gymnastic exercises would be attractive as an interesting daily occupation, but, when practised systematically and in classes by a large body of young men, the interest of these exercises is capable of being intensified to a very high degree.

To render the desire of excelling in them an object of ambition and of strenuous exertion to the great majority of young soldiers, all that is necessary is to establish periodical trials of skill, so arranged as to embrace the whole army in its sphere, and to afford to every individual soldier the opportunity of proving himself the best man at some particular military or gymnastic exercise; first, in his own company; second, in his own regiment; third, in the camp or garrison in which he may be serving; and, finally, in the whole army.

I gave some details in my former lecture showing how such a system of periodical trials of skill might be arranged at an expense not exceeding seven pence per man of the strength of the army. It is unnecessary to repeat these details of an organisation which might be varied in many ways. But I am anxious to take this and every other opportunity of repeating what I then said respecting the important results that would be obtained by adopting, as an integral part of our system of military training, such an organisation based on the principle of discriminating and rewarding individual excellence.

I am convinced that if soldiers were stimulated by the hope of obtaining high distinctions to use their utmost efforts to excel in those exercises which develope the bodily qualities of agility and strength, and the mental qualities of daring and self-reliance, so great an effect would be produced in the feelings and in the capabilities of soldiers as would amount to a complete change both in the moral and physical constitution of the army; converting it, from a body of men feeling little interest in

their duties, and possessing no special aptitude for physical exertions, into a body of trained athletes strongly interested in their daily occupation, and animated by feelings of emulation and the desire of excellence.

The effect of awakening these feelings would be, not merely to ensure proficiency in military and gymnastic exercises, but also to exert a most salutary moral influence on the character of our soldiers—an influence which would counteract, or which would at least be antagonistic to, those evil influences which are the result of idleness and the want of any beneficial and interesting occupation.

Parliament might very likely refuse to vote money merely for the purpose of effecting improvements in military training, the importance of which might not be fully appreciated by any excepting military men; but if Parliament could be convinced that the same means which are essential to the perfect military training of the soldier are also the best that could be employed for the improvement of his moral character, it is certain that the necessary funds would be freely voted.

There is never any hesitation in voting considerable sums for military schools and for good conduct rewards. Is there no one to point out to Parliament that the benefit of money spent in this way is confined to a limited class, and that the same amount of money spent in establishing a system of training adapted to promote the developement of individual excellence would exercise a beneficial influence on the whole mass of soldiers composing the army, and would bring every individual belonging to that mass under the direct operation of a powerful means of moral improvement?

Concerning the time necessary to devote to gymnastic exercises, Major Hammersley considers that, during the whole period occupied in training recruits, one hour a-day should be spent in the gymnasium. The course of instruction there given to the recruit would include exercises with dumb-bells and the ladder plank, adapted to effect the process of setting up in a manner far more efficient, and also far more agreeable than it can be effected by the usual means of extension motions and club practice.

The recruit would also be practised in walking, running, leaping, vaulting, climbing, escalading, and in the various exercises performed by means of the machines of the gymnasium.

At the end of a three months' course even the most backward recruit would be able to perform all the exercises included in Course III. of the system of military gymnastics which has just been issued by the Horse Guards, and in every squad there would be many who would be able to accomplish the greater number of the advanced exercises included in Course IV.

After the recruit was dismissed drill, Major Hammersley considers that one hour a week would be sufficient to keep up the power of performing whatever exercises he had mastered before, while, if one or two hours in the gymnasium formed part of the regular daily routine of the exercises practised by the infantry soldier, progress would continue to be made until in the course of a year or eighteen months each individual soldier would attain the maximum amount of power and skill of which his organisation was capable.

Major Hammersley estimates that with this amount of training two-

thirds of each squad would be able to perform all the arduous exercises included in Course V. of the book.

To give an idea of the degree of muscular development produced by gymnastic training, Major Hammersley has been good enough to furnish me with a table showing the results attained during one year's training in the Experimental Gymnasium at Aldershot.

By this it appears that during these twelve months 1,800 men received instructions, but of this number only 1,363 completed a three months' course, during which time, out of a total of thirty-six lessons, the average amount of instruction received by each man was only nineteen lessons of one hour each.

The average muscular development produced by these nineteen hours exercise was, increase of measurement of chest from $1\frac{1}{2}$ to $1\frac{3}{4}$ inches, of fore arm from $\frac{1}{2}$ to $\frac{5}{8}$ of an inch, and of upper arm from $\frac{3}{4}$ to $\frac{7}{8}$ of an inch. The maximum increase recorded at Aldershot was,

Chest . . .	4	inches
Fore Arm . . .	$\frac{3}{4}$	„
Upper Arm . .	$1\frac{3}{8}$	„

During five months' training at Oxford the increase of one of the Aldershot instructors was,

Chest . . .	5	inches
Fore Arm . . .	1	„
Upper Arm . .	$1\frac{3}{4}$	„

The conditions under which gymnastic training is carried on at Aldershot are by no means favourable for testing the amount of interest which soldiers might be induced to feel in this training; squads from every regiment in camp are marched down to the gymnasium at appointed hours, for a certain number of days ; but, excepting the superintendent himself, I believe that no one exercises any supervision over the instruction which is there given to the men, or takes any cognizance of its success or failure. Commanding officers are naturally indifferent to an exceptional training which will never be repeated—which they know leads to nothing and will not be taken into account by the inspecting general in his confidential report. Individual officers who feel an interest in the experiment occasionally visit the gymnasium to see how their men are getting on, but no systematic regimental record is kept of the amount of progress made by each individual, neither are any means taken to ascertain the comparative efficiency of the detachments of different corps. In short, no means whatever are used to excite an interest in the experimental instruction, and to attract attention to its results.

It is obvious that men cannot be expected to take the same degree of interest in training carried on in this way that they would probably take if a different system were adopted,—if, for instance, at the termination of each course, previous to a squad being dismissed, it were inspected by the brigadier, attended by the commanding officer of the corps; and if periodical competitive trials were established, and small prizes distributed to those who during the course had acquired the greatest skill and proficiency.

Notwithstanding the absence of any attempt to render gymnastic training attractive by measures of this kind, there is sufficient evidence to show that it is popular among the men.

With few exceptions, every man who attends the gymnasium is a volunteer. The great majority of those who receive instruction manifest much interest in the exercises, they work hard and vie with one another who shall make most progress. After a squad is dismissed a good number of the men quartered near the gymnasium continue to frequent it at an hour when it is open to all who have gone through the regular course.

I have prepared the annexed table for the purpose of showing that it is possible so to distribute the time available for training as to allot a sufficient portion of it to each of the different exercises which it is necessary should be practised in order to render an infantry soldier thoroughly efficient in the field. *(See next page).*

Throughout the year one day per week has been allotted to the inspection of kits, and to fatigue. On each of the other five days of the week the number of hours considered available for training, during the spring, summer, and autumn months, *i. e.*, from 1 March to 31 October, are—

From 7 A.M.	to 8 A.M.	1	hour
" 9 "	to 1 P.M.	4	"
" 2 P.M.	to 4 "	2	"
	Total	7	hours.

During the winter months, that is, from 1 November to 28 February, the hours considered available are—

From 9 A.M.	to 1 P.M.	4	hours
" 2 P.M.	to 3 "	1	"
	Total	5	

Calculated according to this distribution, and deducting one-third from each total on account of interruptions from bad weather, guards, sickness, &c., the amount of annual practice devoted to each branch of training will be,

Company and Squad Drill	60	hours
Battalion ditto	160	"
Brigade ditto, 18 days	72	"
Route Marching, 12 days	48	"
Musketry Instruction	296	"
Gymnastic Exercises	290	"
Gun Drill	110	"
Other Exercises	75	"
Total	1,111	

Under the head of musketry instructions I include the practice of the manual and platoon exercises, and under that of gymnastics, setting up drill, the bayonet and sword exercises, and the method of using tackles, and of applying some of the simpler mechanical aids for lifting and moving

TABLE showing Number of Hours per Day, per Week, and per Annum available for the Practice of different kinds of Military Exercises.

Description of Exercise	Spring Practice, March and April							Summer and Autumn Practice, May to October							Winter Practice, November to February							Annual Practice	
	Hours per Day					Hours per Week	Hours in 9 Weeks	Hours per Day					Hours per Week	Hours in 26 Weeks	Hours per Day					Hours per Week	Hours in 17 Weeks	Hours in 52 Weeks	Do. do. deducting ⅓ for Interruptions
	Monday	Tuesday	Wednesday	Thursday	Friday			Monday	Tuesday	Wednesday	Thursday	Friday			Monday	Tuesday	Wednesday	Thursday	Friday				
Squad and Company Drill	2	2	2	2	2	10	90	...	...	...	...	...	...	...	...	...	...	...	...	...	...	90	60
Battalion Drill	1	1	1	1	1	5	45	...	1	1	1	1	4	104	1	1	1	1	1	5	85	234	160
Brigade Drill	...	...	...	...	...	...	...	4	...	...	...	...	4	104	...	...	...	...	...	...	...	104	72
Route Marching	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	...	...	...	...	4	68	68	48
Musketry Instruction	2	2	2	2	2	10	90	1	2	2	2	4	11	286	...	1	1	1	1	4	68	444	296
Gymnastic Instruction	2	2	2	2	2	10	90	1	2	2	2	1	8	208	...	2	2	2	2	8	136	434	290
Gun Drill	...	...	...	...	...	...	...	1	1	1	1	1	5	130	...	1	...	1	...	2	34	164	110
Other Exercises	...	...	...	...	...	...	...	...	1	1	1	...	3	78	...	...	1	...	1	2	34	112	75
Total	7	7	7	7	7	35	315	7	7	7	7	7	35	910	5	5	5	5	5	25	425	1,650	1,111

heavy bodies. This instruction, Major Hammersley agrees with me in thinking, might be very easily and advantageously included in a course of gymnastics.

Under the head of other exercises I include field cookery, pitching tents, constructing huts, and whatever instruction it might be possible to give, without actually breaking ground, in the use of entrenching tools, and in the method of telling off working parties.

For instructing soldiers in the art of field cookery the most effectual plan would be, once a week during the fine season, to cause the men to pile arms on the ground where they usually exercise, and to cook their breakfasts and dinners in the open air. A cooking shed should also be attached to every guard house, in which the men on guard should be ordered to cook their rations.

A master cook, trained in a model kitchen, and thoroughly conversant with the most approved systems, both of cooking in the field, and of cooking by the aid of permanent ovens and boilers, should be attached to every battalion. The duty of the master cook would be to train a cook for each company, and to exercise a general superintendence over the cookery of the battalion. The company cooks would be required to instruct and superintend assistants selected by the rollster for a week's tour of kitchen duty.

After conversing on the subject with Colonel Harness, Colonel Simmons, and other engineer officers, I have become convinced that no instruction of any practical value can be given to troops in the use of entrenching tools, and in the method of constructing trenches and batteries, unless work with the pickaxe and shovel be actually performed.

To exercise the whole of the infantry in work of this kind merely for the purpose of instruction in the same manner that the Royal Engineers are exercised, would involve so great an expenditure in tools and working pay, that the advantages to be derived from such instructions would not be worth a tithe of its cost. The only practicable way of training infantry to the use of entrenching tools is, therefore, to employ military labour to the utmost possible extent for the execution of military works, such as draining, road making, levelling, constructing earthen ramparts, &c. Whenever works of this kind are to be executed one or more regiments should be placed at the disposal of the engineers' department to be employed as labourers. During the time a regiment was so employed its gymnastic training might be altogether suspended, and each of its companies might be relieved from work in succession for rifle instruction. One day a week would suffice for practising field exercises, on which day it would be necessary to relieve the whole corps from work either in the forenoon or afternoon.

It will be observed that in the table I have allotted a very large portion of the soldier's time to gymnastic exercises and to rifle training.

I believe that the time so allotted could not be more beneficially employed, and I also believe that by judicious management most soldiers might be induced to take a great interest in these branches of their training, and to devote much of their time to them without weariness.

I am, however, very far from considering it either necessary or desirable that all soldiers should be obliged to devote the same number of hours

a-day to these exercises. Whether the process of learning be esteemed agreeable or irksome, often depends more in the manner of teaching than in the nature of the thing taught, and there can be no greater mistake in a system of training than to require the skilful to perform the same exercises and to practice them for the same length of time as the unskilful. Marksmen, and soldiers able to perform all the gymnastic exercises included in the prescribed course, should only be required to practice at the rifle ranges and in the gymnasium for such a time and in such a manner as experience might prove to be necessary to keep up this skill.

Having now attempted to show that there is sufficient time available for the soldier to practice all the arts and exercises in which it is desirable he should receive instruction, I shall make a few observations on the nature of the amusements and occupations most suitable and advantageous for soldiers to engage in during their leisure hours.

I shall endeavour to show that, if it be possible, soldiers should be induced to select certain kinds of amusements and occupations in preference to others, which, though of a higher order, have a tendency to create tastes and habits inconsistent with attachment to military service.

A taste for study and for sedentary occupations has an excellent effect in preventing the formation of idle and dissolute habits, but it is apt to render a person sluggish and averse to active bodily exertion. It is therefore desirable that soldiers should prefer out of door sports, such as cricket, hand-ball, hockey, foot-ball, &c., to the in-door recreations of reading, chess, draughts, &c.

Industry, frugality, and prudence are most admirable qualities, but, if we adopt measures calculated to promote the formation of these qualities, we shall find that these same measures tend to destroy that love of adventure, that desire of personal distinction, that recklessness of consequences which distinguish the daring soldier from the sober citizen.

The incompatibility of frugal and industrious habits with those tastes and feelings which are essential to the love of military service has always appeared to me a strong objection to plans for the formation of regimental workshops, and I am surprised that the force of this objection does not seem to have been felt by any one of the many distinguished soldiers who advocate and promote these plans.

It has always appeared to me that the injury done to the military spirit of the soldier would be in proportion to the success of their plans in effecting a reformation in his moral habits. A soldier who in acquiring a trade had also acquired the frugality and prudence, and the desire to save money and to better himself in the world, which are the characteristics of an industrious tradesman, would, I think, inevitably imbibe a distaste for his military duties, and would eagerly seek for an opportunity of quitting the service. On the other hand, where the plan failed in its moral effect: In those cases where an idle and dissolute soldier acquired skill in a trade without his habits and tastes having undergone any change, he would merely have acquired a means of obtaining money to squander in drunkenness and dissipation.

Whether successful or unsuccessful in promoting the moral improvement of soldiers, the operation of the plan would inevitably be injurious to their military efficiency. Now, if an army is to be maintained at all,

military efficiency ought certainly to be the first consideration. The value of any particular amusement or mode of employing the leisure time of soldiers ought therefore to be estimated chiefly and primarily with reference to the effect it is likely to have on their military efficiency, and, if reference be made to the influence it is likely to exert in promoting their moral improvement, this ought only to be treated as a secondary and collateral consideration.

The first enquiry regarding any proposed method of occupying the leisure time of soldiers must be :—Will it promote their military spirit and increase their attachment to the service? and it is only after this question has been answered in the affirmative that we are permitted to enquire:—Will it tend to prevent the formation of dissolute and drunken habits? Arranged according to this principle of estimating their value, the different methods of providing occupation for the leisure time of soldiers may be thus classified:

1. Military and gymnastic exercises, such as rifle shooting, running, leaping, vaulting, climbing, &c.; though all these should be included in the regular routine of a soldier's training, yet means should also be taken to induce him to devote a portion of his leisure time to their voluntary practice;
2. Out of door amusements, such as cricket, football, &c.;
3. Attendance at the regimental school, and at instructive lectures, especially on military subjects;
4. Social amusements, such as amateur theatricals, concerts, &c.;
5. Sedentary recreations, such as reading, chess, draughts, &c.;
6. Industrial occupations.

I shall now venture to submit to you a few conjectures respecting certain modifications in the order of formation and method of handling infantry in the field of battle, which I think it may very possibly be found expedient to adopt in consequence of the change which will be introduced into the conditions of attack and defence, by arming infantry soldiers with weapons of vastly increased accuracy and range, and, by means of careful training, teaching them the art of using superior weapons in the most skilful and effective manner.

The obvious result of these measures, and of the substitution of rifled artillery for smooth-bore guns, will be to render it far more difficult and dangerous for a soldier to close with his foe than it ever was before. He will be exposed for a greater length of time to a more effective fire. When the defence of a position is conducted under conditions favourable to accuracy of aim, the loss suffered by the attacking troops will be so severe that the advance of the boldest soldiers will frequently be checked.

It may, therefore, be expected that close combats will become less frequent than ever, and that the average distance which separates contending armies will be greater than it used to be. Every movement will extend over a greater space, and will require a longer time for its completion. If flank movements, or extensive changes of position, are attempted, the whole day will be consumed before the attack is sufficiently developed. Protracted defence will become easier; rapid attack more difficult; decisive results will more seldom be attained.

Success will, in a great measure, depend on the possibility of making

such arrangements as will secure to troops the advantage of fighting under conditions favourable to accuracy of aim. To secure this advantage in the greatest possible degree, two expedients suggest themselves as likely to be employed, first, the creation of artificial cover by the indefatigable use of the pickaxe and shovel; and, second, the substitution of a looser order of battle for the present formation of two ranks at close order.

Not only may it be expected that, in making even the most hasty arrangments for the defence of a position, rifle pits and such parapets as can be thrown up in a single night will be considered indispensable, but it even seems probable that it may be found impossible successfully to attack a position so strengthened without resorting to methods similar to those which are made use of in approaching a fortress. On the night before a battle it is possible that it may be found necessary to push forward working parties, and to provide cover for riflemen near enough the enemy's position to reach the hostile batteries with their fire.

Instead of positions being assailed and defended by infantry formed in two ranks at close order, it seems also probable that a more effective fire will be obtained by adopting a looser formation, so as to admit of the front and rear rank men changing places, each soldier delivering his fire in the front rank, and then falling to the rear to load.

This could easily be managed by deploying with intervals between the companies, so as to admit of the files opening out from the right to the extent of a pace, or half a pace, when the firing commenced.

In order to obtain the greatest possible results from the fire of skirmishers, it will probably be found that, instead of extending one or more complete companies, it will be better to employ none but marksmen and first-class shots in this important duty. Those belonging to every company in the battalion being ordered to the front, under the superintendance of a field officer, assisted by the musketry instructor, or by any other officer who might be selected as specially qualified for the duty. If only a few men were required, or if the enemy were barely within rifle range, only marksmen would be employed. If a greater extent of ground had to be occupied, or if the enemy were closer at hand, the marksmen might be reinforced by the first-class shots of one or more companies.

Similar arrangements might be made for defending an intrenchment. At first, while the attacking force was distant, none but marksmen should be allowed in the banquette. As it approached, the first-class shots might be ordered up, and for the defence of the last 300 yards the fire of every man in the ranks should be employed.

To check the advance of cavalry a line of company squares would, I think, be found preferable formations to the ordinary battalion square.

In a battalion of ten companies the front of the line of company squares would exceed the front of the two end faces of the battalion square in the ratio of ten to four, and that of the side faces in the ratio of ten to six, or, allowing for the flank men of the two front and the two rear companies, say in the ratio of ten to seven. In a battalion of eight companies these ratios would be eight to four and eight to five, and in a battalion of six companies they would be six to four and six to three.

The efficiency of the fire of the line of company squares would admit of being very greatly increased by causing the marksmen belonging to the

rear sections of each company to run out a few paces on the flanks, and thus to fill the intervals between the squares by a line of skirmishers who, as the cavalry approached, would resume their posts in the squares from which they had been detached. In case of the cavalry charging home, it would probably be impossible to prevent the horses from swerving and passing through the intervals, but even if they did succeed in breaking and riding over one or two of the squares the formations of the others would remain unbroken.

The same change in the conditions of warfare which renders it so advantageous that troops should fight as much as possible under cover and in the formation most favourable to accuracy of aim, renders it scarcely less important and advantageous that they should be so trained as to be able to move with rapidity, and to traverse long distances in a short space of time. The quicker they move while under fire the fewer will be their casualties, and the greater the distance to be traversed the more important does it become that the time of passage should be as short as possible. Moreover, since a few minutes difference in the time of the arrival of supports is very frequently that which determines whether an effort shall be successful or a failure, it is obvious that, if it be necessary on account of the increased range of projectiles to make dispositions which increase the distance supports have to traverse, it is a matter of the most essential importance that the rapidity of the pace at which the supports move should be accelerated to the greatest attainable speed.

I believe that the superiority of the French to the Austrian troops in the power of rapid movement was one of the chief causes of the successes obtained by the Emperor in his late Italian campaign; and I cannot conclude this lecture in a more appropriate manner than by reading to you an extract from a very interesting letter, addressed to Major Hammersly by Major Adams of the Royal Military College, in which are related several notable instances of most essential services rendered to the cause of the Emperor by the rapidity with which particular corps moved from point to point. Major Adams, relying principally on the statements of foreign writers, says:—

At Montebello two battalions, having previously taken off their knapsacks, advanced at the double to Forey's support, from Voghera to Fozzagazza, a distance of four and a half miles.

At Magenta the Division Renault, leaving their knapsacks behind them, completed the distance from Trecate to Ponte Nuova di Magenta, a distance of nearly seven miles, at a running pace (pas gymnastique), entering the line of fire immediately on its arrival.

In the same battle, on the French left, two battalions of Turcos doubled from Casate to Buffalora, 3,000 paces, to Lamotte Rouge's support. Similarly la Garde Voltigeur (Camon) from Turbigo to Buffalora, five and a half miles.

At Solferino towards the close of the day, when Niel was so hardly pressed, Canrobert, after inexcusable delay, detached the Division Renault from Medole to his support. The whole division, leaving its knapsacks behind, doubled to its destination, nearly two miles.

In almost all the cases cited, the opportune appearance of the supports at the decisive point, turned the issue of the different actions in favour of the French. Their columns of attack habitually advanced at the double from the moment they came within range of their adversaries' rifles (800 to 1000 yards), and never slackened their pace until the object of their attack was reached. Had the French not been

previously trained for a long time to double for long distances, and to execute at this pace the manœuvres of large bodies of men, not only would their actual losses have been greater by one-third at least, but it is exceedingly doubtful if they would have been able to carry many of the strong positions against which they were pitted.

Some of the statements made in this letter will doubtless be heard with surprise. That large bodies of troops should double from five to seven miles does indeed seem incredible. Perhaps it is not meant that they kept up the running pace throughout the whole distance, but merely that they moved at a rapid pace, alternately running and marching. It would have been satisfactory if the time in which the distances were performed had been stated, as this would have fixed the rate of movement with precision.

The following anecdote was related to me by Colonel Simmons, who heard it from an officer attached to the staff of the Emperor Louis Napoleon, an eye and ear witness of what he described:—

After some time had been spent in unsuccessful attempts to carry the village of Solferino, the Emperor, turning to an aid-de-camp, said, "Apportez moi la Garde." An instant afterwards, correcting himself, he said, "Non, pas la Garde, mais la Garde Voltigeur." La Garde Voltigeur arrived, was formed for the attack, and ascending a long steep hill at the double without a check carried the village of Solferino, the key of the Austrians' position.

This incident was mentioned to Colonel Simmons as a proof of the great coolness and self-possession of the Emperor, but it also serves to illustrate the manner in which the French troops employed in the Italian campaign made their attacks, and to confirm the statements reported by Major Adams.

Is there any regiment in the British Army which could at this moment move in the manner these French corps are reported to have moved?

Is there any regiment which after six months' proper systematic training might not be matched, both for speed and endurance, against the troops of the most warlike European nations?

Friday, May 30, 1862.

H.R.H. the Duke of CAMBRIDGE, K.G., General Commanding-in-Chief, in the Chair.

THE LINES OF LONDON: DEFENCES BY WORKS AND MANŒUVRE IN THE FIELD.

By Col. Adair, F.R.S., A.D.C. to the Queen.

Colonel Adair.—May it please your Royal Highness, Ladies, and Gentlemen,—It may possibly be within the recollection of many of those who have honoured me with their presence on this occasion, that this is not the first time on which I have been permitted to develop my ideas as to the defence of the metropolis. On the last occasion two elements of calculation were wanting, which have now materially, I may commence by saying, modified the principle on which I propose to construct the works which are detailed on this model. Those two elements are, the Use of Rifled Ordnance at Long Ranges, and the Establishment of the Volunteer Army.

Before I proceed I would, however, say, that I should not have ventured to treat a question of this great importance if it were not one submitted to public discussion now for many years in the most decisive and distinct manner by the proceedings of the Commission of Defence, inaugurated by order of Her Majesty's Government. When I find an inquiry made of one of the leading men of the great commercial interest of England, what the effect upon English credit would be if the capital were occupied by a foreign force, I have ventured to think it has become not simply a privilege, but a duty, on the part of any private subject of the Crown to discuss this subject, particularly when he has the opportunity and the advantage of having it submitted to the officers of the army who are here present. For, indeed, the fortification or the defence of London is not simply a representation of the defence of a frontier fortress, or even of a capital exposed by position to severe attack, as on the Continent; it represents the resolve of a great commercial people, that, while they have in no degree forsaken their attachment to the industrial efforts and the pursuits which make peace lovely, yet they are determined, so far as is consistent with human power, to protect that capital which is, as it were, the very heart of the English system. For that which affects the commerce of England, and its concentration in the metropolis, more or less directly affects the commerce of the world. The pulsation that proceeds from London extends a vibration through the remotest haunts of civilised man. Therefore, the object being of such im-

portance, and being, as I said, cast before the public for consideration by the proceedings of the British Government, I hold that it is our duty to bring the problem, if not to a solution, at least into the condition to receive a practical solution. And I am quite sure that on these grounds I shall meet with the indulgent consideration of those whom I have the honour to address.

In the first place, I object strongly to the proposition to dissociate the commercial and the military centres of England. I can quite understand—I admit most completely—that the Arsenal of Woolwich is a too precious possession, as a centre for the deposits of our military strength, to be needlessly exposed to attack; but, while we remove the means of reproduction of the materials of war from risk of sudden attack, there is, as it seems to me, no reason why we should divest Woolwich of its military character as a great depository of stores; still less, why, by abandoning Woolwich, we should subject London to be considered as an open town, to be the prey of the first assault. For it must be borne in mind that for many years the defenceless position of London has been an object of consideration elsewhere. Of that there is no doubt. We have heard it avowed openly; we have heard it hinted secretly; we know it to be a fact. Therefore it is, we must withdraw that perturbing element from the equation of our foreign policy. And this difficulty I found in endeavouring to work out the problem which I have attempted. I do not desire to stifle London, as it were, within lines of works which would prevent her free action, and materially change the character of the metropolis. But on investigating the disposition of the ground I find, as I have maintained heretofore, that London, under all the circumstances of its position, with reference to the genius of its people, considering also the rapid and converging communication which it possesses, is one of the most defensible capitals, if not the most defensible, in Europe. That I shall endeavour to make plain in the development of my idea during this lecture.

Now, with respect to the system to be adopted. On the first occasion of which I spoke, the two great elements of defence, to which I now attach great importance, were absent, and my idea was to provide forts mainly on the bastion system, and therefore of small capacity, and subsequently to construct continuous lines. The positions which I then occupied are much the same as those I propose to occupy as the internal, or alternative, line of defence on the present model. But I have been obliged to go far beyond that zone of defence, and for this reason: In the first place, the bastion system is intricate and complicated; it requires a large proportion of scientific outwork, and it gives very small spaces for the masses it may have to receive in the last result. For that reason I abandon the idea of the bastion system. Again, viewing the conditions under which artillery fire is now projected, and that the chief danger of the metropolis lies in the risk of conflagration, it appeared to me imperative to remove the zone of bombardment as far as possible from the dangerous point of conflagration in the city. It was then necessary to select a system of an appropriate type. I found in the plastic character of the polygonal system, as adopted generally in Germany, and which has now been applied to a considerable extent in this country also, the resources which I required.

But, in passing from the bastion system to the polygonal, there was another element of calculation to be weighed. It is certain that the power of projection has always been the unit of calculation in defensive war. The walls of Aurelian have their towers, as may be seen at this day at Rome, just distant from each other what the double "jactus pili"—the heavy javelin of the Roman soldier—could cover. The same principle which prevailed in the walls of Aurelian, passing over the calculations of M. Vauban, has been adopted by English engineers, as may now be seen in the lines of Stoke's Bay, where 600 yards is substituted for the 360 yards of M. Vauban. Consequently, I adopted 600 yards, trusting to the range of the English rifle as the unit in defensive lines for the maximum of calculation in the line of defence, and also of armament of the works when constructed.

With regard to the construction, having prepared the trace on the principle which I stated, I found that it was abundantly necessary that these continuous lines should be supported throughout by works capable of a substantive defence. Again, in reliance on the simplicity of the polygonal system, and trusting to the heavy mass of fire by which the defence of such a capital must be supported, I am contented with very few advanced works. The ravelins that are attached to the Prussian and the German system, the caponiers which are intended to give a flanking defence, are all that I have adopted. In fact, I have endeavoured, by heavy masses of earth, such as shell fire shall be almost powerless to disturb, by a ditch of unusual capacity and depth, by the concentration of the fire of rifled ordnance on all points that are subject to attack, to compensate for that more intricate and expensive system which Vauban originated, or at all events developed in its completeness.

With regard to the arrangements of the works for the defence of London, I find London, for the purpose of defence, commencing from Woolwich, and passing round its complete exterior, to be an octagon, of which the sides amount to 55 miles 944 yards. I break up this octagon into lines of manœuvre, for I am not content to retain the troops that should be sufficient for the defence of London ingloriously behind their continuous works; and I consequently adopt the sides of the polygon as lines of manœuvre on which troops may move, supported by the fire of artillery in position. From Eltham to Anerley one line of manœuvre would extend; from Anerley to Kingston a second; from Kingston to Twickenham a third; from Twickenham to Hanwell the fourth; from Hanwell to Harrow the fifth; from Harrow to Hendon the sixth; from Hendon to Stamford Hill the seventh; and the eighth from Stamford Hill through the marshes of the river Lea to East Ham. These lines would form the eight fronts of the polygon, and the eight lines of manœuvre. With regard to Woolwich, I am aware of a difficulty in the defence of the Arsenal from risk of fire therein; yet it would seem exaggerated, for this reason:—In the first place, there is a broad screen of hill interposed between a large proportion of the Arsenal buildings and the possible emplacement of powerful batteries; between that large surface of workshop, factory, and storehouses, which might by their conflagration impede the defence, we have the obstructive power of works, armed with heavy ordnance, extended along the eastern slopes of the hill,

and we have the means of projecting preponderating masses of mortar-fire from the crest. But Woolwich, as it does not afford space for manœuvre in the field, and for the considerations I have mentioned, must rely on its substantive strength as a fortress. I propose to connect the upper and lower lines of batteries of Woolwich with the rolling ground on the south-east; to place casemated batteries on the slope of the hills, and mortar batteries to search the hollows of ground which afford cover to troops in formation, and approaches to sunken batteries of bombardment.

I propose a polygonal fort to defend the rear of Shooter's Hill, and to throw an auxiliary fire athwart the Thames, and aid in the defence of the lines in the Essex Marshes. The guns of this fort will also sweep that portion of the long line of valley which passes across the high road, and so, leaving Eltham to the left, is traced by Mottingham Hill, on the western slope, to a redoubt which lies north of Beckenham. Woolwich, as regards its garrison, would be held by a portion of the regular army. I calculate the armament on a special scale, as follows. In consequence of the adoption of the polygonal system and a new unit of calculation, it became necessary to establish what I will call equivalent fronts of construction and of defence. I interpret the equivalent front of construction to be the 600 yards of the polygonal system, compared with 360 yards of the bastion system, and, if so, it is also the equivalent front of armament. Now there exists a scale which has been tested on many occasions in the defence of regular works, which allots to a front of fortification 11 guns, 6 mortars, and 2 field guns = 19 guns. Now this proportion was calculated on the special service at particular stages of the siege, against enfilading and breaching batteries, against lodgments, and the like incidents. But, on the principle which reduces the siege-operation to one simple event, I preferred to select a single calibre of gun, the 40-pounder Armstrong; and I tested the value of the 40-pounder Armstrong, against the aggregate power of these guns, under the novel qualities of increased range, heavier metal, and rapid fire. The result was this, that, excluding mortars and field guns, for which I provide elsewhere, in the question of the preponderance of force compounded of range, momentum, and frequency of impact, I can, with eight 40-pounder Armstrongs, throw more effective weight of metal than with the 11 guns which are allotted on the original war scale, regard being always had to the increased range and rapidity of loading, which last, however, I do not estimate very highly. This brings me practically to one 40-pounder Armstrong for every 75 yards. Now, the principles of defence which I am describing do not so much express operations of siege-resistance, except in their application to the forts and redoubts, as to field fire in disturbance of the enemy's formations. I attach much greater value to accuracy and distinctness of fire, than to excessive rapidity, which produces a salvo, but not the crushing effect of concentrated fire.

I now come to the arrangements which I propose for the lines. I have endeavoured, as far as possible, to avoid the greatest danger on these long lines, that of enfilade. I have, therefore, so planned the trace that either the prolongation should fall on inaccessible ground, which would rarely happen in this country, or on ground on which the defence can accumulate a larger weight of metal than an enemy could project. For instance,

it appeared doubtful whether Eltham should be occupied, but I preferred trusting to the mass of fire which could be delivered from the south-west angle of the lines on the Woolwich system to occupying the plateau. But there is another point with regard to the use of these forts and redoubts. I propose, in the first place, lines of manœuvre external to the continuous lines ; if a reverse should occur there is a means of defence by the continuous lines ; or if any portion be pierced, and the flank turned, and the parapet reversed, two means of defence remain in reserve; the flank and rear fire of the works and redoubts will sweep these lines in reverse; and, secondly, they will serve as *points d'appui*, or standing flanks, whereon to renew the engagement, which may have had an unfortunate event on the ground exterior to the lines.

The command given to the works over the country is twenty-two feet. It will be observed that the minuter details have been suppressed entirely, in order not to complicate the plans; I have not given the traverses, the flêches that cover the passages through the lines, or the magazines. I have simply indicated the position and the form of the proposed works.

The first line of battle having been traced from Eltham to Anerley, the troops are disposed in nineteen battalions of infantry in advance of the works. The strength of the garrison is assumed on the ordinary calculation of two men to each yard of musketry parapet. This gives 180,000 infantry, and in comparing my calculation with that which has generally obtained, especially in the French service, I find a very satisfactory agreement. For instance, taking 180,000 men for the infantry that London is bound to supply—and in my judgment, if this metropolis cannot supply of its own citizens 180,000 men for its defence, the defence of London must be desperate indeed; 21,920 artillerymen for the 2,192 guns, with which I propose to arm the works; and 4,500 cavalry in the ordinary proportion, I get an entire garrison of 206,420 men.* Calculating on equivalent fronts on the principle of Cormontaigne, as approved by Carnot, on the principle of Lesage and of Noizet, and of the Commission of Defence of the present French Government, I find that for the hexagon, which coincides to a considerable extent in essentials to the proportions of my lines, the estimate varies from 199,800 to 228,000 men against 206,420.

I then proceed from the Anerley redoubt, by Mitcham, in front of Coombe, to Surbiton, on the South Western Railway. This portion of the line requires very considerable care in its defence. Few accidents of the ground lend themselves very satisfactorily to the defence, but redoubts have been placed in such positions as may give standing flanks from manœuvring distance to distance, and the infantry of manœuvre is interposed at the points mentioned, with the power of moving up reserves from the interior on occasion. The practical result of such works will be shewn hereafter.

A disadvantage of long and continuous lines is in moving infantry from within the enceinte in order of battle. Some excellent remarks on this subject were published by Sir William Reid in the Professional Papers, R.E., from which I derived considerable information. I therefore determined to ascertain whether I could not, in default of a covert-

* Lt.-Col. Kennedy's calculation gives 122,375, being 4-20ths of males capable of bearing arms within these lines.—*Journal R. U. S. I.* vol. iv. p. 60.

way, which would have given external *places d'armes*, prepare *places d'armes* within the lines, which should at the same time give facility for filing out battalions in order of battle. The exterior side = 600 yards, dropping a perpendicular of $\frac{1}{12}$, and taking $\frac{1}{3}$ of the exterior side as a line of defence, at the point of the perpendicular, and at the distance of the shoulder angle, I trace an arc of which the chords form the interior sides of the *place d'armes*. The result I have established is, that the battalions, being formed in rear of the line, file through a postern gate, in the re-entering angle, into this *place d'armes*, and remain, if necessary, in columns of companies, since the width of the ditch will enable any movement to be made in such formations as may seem expedient. Again, if the line of defence be traced to the point where it falls on the shoulder angle, it will be observed that the troops in column are perfectly secure from any bounding shot, or from any but vertical fire.

I proceed to explain the armament with which I propose to defend the shoulder angles. I set off thirty yards on either face, which is to admit of construction in concrete for the establishment, in the first place, of embrasures on three lines of fire perpendicular to the parapet. It is essential that the fire should be perpendicular to the parapet when a defence must be conducted, to a great extent, with troops who may not yet have had a thorough training, which makes it necessary to deliver fire on a perpendicular to these three embrasures. At the point of convergence of these lines, I place a turntable, designed to facilitate the entry into its proper embrasure of a 40-pounder Armstrong gun on a garrison carriage. The simpler the arrangements the better; and if the Armstrong gun be kept on the permanent, and not on dwarf, platforms, it may be used at once at any point to which it may be transferred, for, although the possibility of a general assault on London is assumed, still no soldier will believe that such general assault is probable; and therefore any gun may be withdrawn for reinforcement of an adjacent battery when not required for service. The result then is, that I obtain the means to fire under cover through an angle of 135 degrees; these guns sweep the country, and after a certain point they sweep the ditches. But, in order to secure the perfect command of the ditches, at the base of the scarp of the shoulder angle is placed a small battery of carronades on garrison carriages of wood, which I prefer as simple guns to any others for sweeping the ditches. The first attempt in an attack upon the lines by scientific means would be to attach the miner to the shoulder angle; therefore it is imperative that no sap should cross the ditch with impunity. There is, of course, from the very great thickness of the parapet, dead ground at the foot of the scarp, which will require to be swept by musketry, and a small loop-hole gallery is built in the re-entering angles for that purpose. Then, filing the battalions through the ramparts of equal breadth with the ditch into the country, they pass a traverse, designed to cover the ditch at the salient from direct fire. This mass is left in the counterscarp at the junction of its salient, and the prolongation coincides with the superior slope of the parapet; consequently musketry from the salient of the rampart can see to the foot of the traverse.

For the defence of these lines 30 battalions are allotted, and in the event of check, the lines being forced or turned, in the re-entering

angle contained within the Ridgeway at Wimbledon, and the high ground of Tooting and Streatham, I find a space within which the assaulting forces would operate with disadvantage. For an interior line of operations is useful so long as it can be maintained, in order to establish unequal distances between exterior lines, but so soon as the troops moving on exterior lines include the manœuvring force, being equidistant from each body, especially if confined within a right angle, then the assaulting force, being as one to two, must suffer loss on all ordinary calculations.

Passing then to Surbiton, which lies on the south-western slope of Kingston Hill, it appeared impracticable to include it with any satisfactory engineering results within the lines; consequently a redoubt is placed on the crest of Surbiton Hill, which gives its fire in reverse, to protect this angle. The work towards Kingston Hill also combines with artillery lines on the descending slope to the westward in throwing a flanking fire over Kingston, and on the flank of Kingston Bridge head, near Hampton Court.

I now come to the combination of lines of passive defence, so to speak, and of manœuvre. For reasons which I have published, my impression has been that the weight of attack in an invasion will inevitably follow the course of the Thames. In a former plan, published in 1860, I have shown the route which army corps must presumably follow, and in all these cases I have accommodated the theory to the face of the ground, as causing a certain line of march to be adopted. Assuming then that the weight of attack falls especially on the south-western side, it will be favourable to manœuvre, and manœuvre is precisely the quality in which an invading army will presume that it excels the national forces. Easy access across the river, and an easy mode of returning, if necessary, must then be provided. At the various points indicated I have prepared bridge-heads, which are traced on the sides of a triangle, whose base is coincident with the long axis of the main stream. The sides being determined, the flanks are drawn as a matter of course. Crossing the river at Kingston, at Teddington, at Twickenham, and at Richmond, I have formed these bridge-heads. Now, a very remarkable assumption has been brought under my notice, namely, that Teddington Locks control the lower Thames; that is to say, if Teddington Locks and Weir were broken down, and the river swept clear of those constructions, the river above would become fordable; and that, if the locks were then simultaneously opened, the first tide would rush to the sea with a violence that would affect the shipping in the river, and that, if they were then closed, no subsequent tide would hold up a sufficient accumulation of water, and the metropolis would be thus deprived of one means of obtaining a supply. I have accordingly protected Teddington Locks with a sufficient bridge-head. For the line from Kingston Bridge head to Twickenham Bridge twelve battalions are allotted. I might take occasion here to say that an advantage which would immediately result from taking lines of such an extended sweep is, that the value of land becomes inconsiderable; and that there are very few points where I have interfered with property, because I hold that the defence of London must be popular and national, as well as scientific, and that we are bound, therefore, to consult individual convenience, so far as it is consistent with

public duty; for the nation would rather pay more largely for the construction of these works, and more readily equip troops for their defence, if it knew that the cottages of the humble were respected no less than the dwellings of the wealthy in the arrangements made in defensive details. I may here mention this, because the point at which I have most sinned against my own canon is at Isleworth. Being unwilling to project the lines too far into the plain, I have taken in Isleworth Redoubt a small amount of property. This is flat ground. I supplement the want of a great body of infantry on the spot by a cross-fire of artillery. Passing thence the defensive line of the Thames level, as continued to Boston, and completed to Hanwell, at the viaducts on the Great Western railway, this system of defence rests on the valley of the Brent. From Twickenham Bridge head to Hanwell 14 battalions are distributed.

It is to be remarked that a very large proportion of the lines of London is susceptible of defence by inundation. For instance, the whole valley of the Lea, and of the Brent, a large proportion of the ground where the stream enters Richmond Park, the line of the Wandle, of the Ravensbourne River, and of the low ground beneath the prolongation of the Ridgeway—all these points are capable of affording a large defence by inundation. For this peculiar advantage is incident to the defence, that the outfalls of the streams lying within the lines are completely under control, and the dams and sluice-gates cannot be destroyed by the fire of field artillery. Crossing the valley of the Brent, I arrive at Horsington Hill, a most remarkable position, which dominates the lines and intrenched works on the north-west slope of Castlebar Hill. This hill is not generally known to the inhabitants of London. It is not visible from the Harrow Road, and, except to those who stand on the crest of Castlebar Hill, is not visible from the southward. It rises steep from the flat meadows of Perivale, with an easy slope from the north. As a point of observation and reinforcement, it is of very great value. I have consequently traced artillery lines, and constructed mortar batteries and casemates on its exterior faces. The proportion of infantry from Hanwell to Horsington Hill is 12 battalions.

Then came the question of Harrow. Harrow projects a narrow plateau of considerable emergence, and, therefore, of difficult treatment, into the north-west. Still, Harrow must not be abandoned. I felt this also, that, as one of the great centres of our system of education, it should be respected in its entirety, and preserved, as it were, inviolate from engineering operations. I am confident that those who have an interest in our great public schools will appreciate this forbearance. But the ground is very difficult. It is divided into ridges, which afford points for the formation of troops, without giving any very great facility for projecting works of defence. Consequently the Harrow lines are reinforced by a system of cavaliers, which the continuous ascent facilitates. But at the salient this question arose. A work of a very peculiar kind was required, which would give flanking fire, reverse fire, and also sweep the approaches, a very large work, and yet not liable to the destructive effect of vertical fire concentrated on an equilateral parallelogram. But in the Professional Papers (vol. ix.) by which the Royal Engineers have enriched our scientific knowledge, I found a plan prepared

by Colonel Bainbrigge, R.E., to which I am indebted for the trace of that redoubt. It is a redoubt of peculiar efficiency, and was originally designed by him in connection with the defence of a continuous enceinte, and is defensible by a garrison of from 100 to 200 men. From Horsington Hill to Bainbrigge Redoubt eighteen battalions are assigned to the defence. From Harrow the next line of battle passes to Hendon, and is maintained by thirteen battalions. At a distance of 1 ⅛ mile S.S.E. rises Woodcote Hill, on which is constructed a polygonal fort, and on the right rear Barnes Hill uplifts slopes on which works may be constructed to combine direct fire with Woodcote Hill, and also to sweep in reverse the lines which connect Harrow with Hendon. On the right front, on the left of the Edgware Road, The Hyde, at an elevation of 289 feet, dominates the country in advance, as an armed salient to the Harrow and Hendon districts. At Hendon a polygonal fort has been constructed according to the natural distribution of the faces. These works cover also the Brent reservoirs, it being of exceeding importance to maintain the command of the water, both fluvial and in reservoir, which is to supply our metropolis. From Hendon the line then passes to Muswell Hill, requiring thirteen battalions. A redoubt on Clatterhouse Green to the S.S.E. maintains, in connection with a smaller one on Golders Green, continuous fire to Child's Hill. Supposing it to be a direct assault against this re-entering angle of the lines, a redoubt constructed on the Finchley road above the cemetery directs its fire against flank and rear of an attacking force, and searches the hollows. From thence the line passes to Muswell Hill, of which the northern slope is of considerable steepness, and therefore must be defended by musketry fire rather than by direct artillery fire. On the crest of the hill it became necessary to construct a work which would give fire from four fronts, and also prevent the occupation of the eastern spur of the hill. Now, on Muswell Hill I found that the ground is of that treacherous and uncertain quality that, except at enormous expense, it would not have been possible to raise any work suitable to the position. On the crest, or rather at the *col* or neck of the hill, close to the church, a work is constructed which gives a fourfold front of fire; one sweeping the sloping ground to the northward, another giving its fire to the front of Highgate Hill and Child's Hill, another looking into the low ground about Hornsey and Crouch End, and another accumulating such a front of fire on Muswell Hill as would render it impracticable to construct works either of siege or of permanent investment. Then descending the Great Northern line, and passing by the New River to Stamford Hill, there is a redoubt on Crouch End, and artillery lines secure the plain below in the direction of Tottenham. For manœuvring twenty-eight battalions are detailed, with a reserve of twelve. The last line of manœuvre commences in the valley of the Lea, and demands the services of twenty-seven battalions.

The difficulty of establishing works in the valley of the Lea arose not from the risk of inundation, but of interference with property on the south-east portion of the lines, and from the danger of bringing the works under the control of the slopes to the eastward. I had at one time proposed to establish a system on the principle of Cohorn; but the usual objection to the employment of the bastion system, namely, intricacy of trace, and confined space, prevailed. The intricacy was found to be so

great in a level interrupted by frequent water-channels, that I was obliged to abandon it, and I have substituted artillery lines, closed at the gorge, as redoubts, and resting on the right flank on the great redoubt at Plaistow, and on a polygonal fort at East Ham. The lines are observed by a heavy work on the plateau of Clapton, a heavy work near Victoria Park, and a smaller one on a rising ground at Bromley Marsh. The general infantry reserves are fifty-nine battalions, distributed on the railway junctions.

Such are the trace, the distribution, and the components of the first line of works. I will now proceed to develope the interior line. As I have stated, the first line of defence is composed of troops manœuvring in the field, with the support of batteries and heavy works. They have the alternative of manœuvring in the field, and falling back, and forming on these works as standing flanks. The map will show what my proposition would be in the event of these lines being forced, and the heavier works left to maintain a substantive defence. It will be remarked, that on the model nine points are indicated by engineering cairns. These represent the positions between which the intervals would be available for defence by infantry and field guns. The works have not been introduced in plan to avoid complexity, but can be readily supplied by the experience of any officer, and are shown in the map of manœuvre by circles. I have assumed the same proportion of battalion front for the defence of the interior lines as on the exterior. The reason of that, as will be seen, is, that I wanted to test precisely the relation in tactical equation between a combination of troops supported by standing flanks and batteries, and of such as have limited points of support from forts while manœuvring on a smaller surface. The inner line of defence bears to the outer line of defence the proportion of 5 to 8. The number of forts is the same; but on the exterior line 34 redoubts and 6 bridge heads give support to the troops in line of battle. And it will be observed that the external line of battle is formed with supports and reserves, but that there are not troops enough for such disposition on the interior line. Now, that fact is very important. Every postulate should be reduced to a mathematical expression, and thus it is shown, that, whereas the interior line of defence is 35 miles, while the line of exterior defence is 59 miles, yet the battalions formed on the shorter line are not brought into such close contiguity, are not in such an available line of battle, as those disseminated over a larger surface, being supported by standing flanks and batteries. From which I would draw this conclusion, that the value of a line of battle formed on works capable of substantive defence, and supported by redoubts and batteries, is to an equivalent line of battle formed on works alone as 8 to 5, the advantage being nearly one half to the line of manœuvre consolidated by occasional works and artillery lines, and consequently by field-works and batteries of position.

With regard to internal arrangements, the facilities that the railway system gives for maintaining communication must not be overlooked. At the convergence of these lines are points at which the reserves are placed *à cheval*, from which they can be directed on any line of battle. Taking the lines westward, and southward, and north-west of London, every division has a reserve within a quarter of an hour of the line of battle. The greatest distance is about six miles. If I be correct in that estimate, the railways multiply the power of reserve, as compared with the ordinary marching

of troops, to a point ranging from 8 to 16: that is to say, 20,000 men in reserve on a railway would be raised to some numerical expression varying from 8 to 16 times in their arrival on the field, and therefore in defensive momentum. But if a railway prepares, accelerates, and assists the decisive strokes of battle, on the other hand it multiplies the losses of the defeated force. In the defence of a country in which there is no railway, the retreat is a withdrawing from the front; but on a railway it is a congestion of forces. The victorious army would act with largely increased power on a force retreating on the narrow line of a railway, which would necessarily be without a knowledge of lateral communications to relieve the crowded columns of route. This is an inconvenience to be guarded against. If masses of troops be projected by a railway on a field of battle, their subsequent retreat should be prepared more carefully than if they retreated by parallel columns across the country.

Now, having explained these views so far, there are some points which I cannot permit myself to pass over, as touching the position of London itself. I have said we all feel that the defence of London must be national and popular, as well as scientific. It is not the mere defence of a fortress, nor is it a defence that can be permitted to be unsuccessful. More lies on the defence of the metropolis of England than the mere abatement of any power and influence that belongs to the sceptre of the sovereign beyond the seas. I dissent entirely from the opinion, that, if London were captured, on that ground national resistance should be abandoned. By no means. But the blow would be a severe one, and a blow that would require no ordinary fortitude in the country to meet. There are disturbing influences of a social character which are anticipated in the case of such an event as an attack on London. In the first place a real and very serious one is that of conflagration. I know that conflagration may be rendered harmless, or, at all events, detained in quarters of the capital where its ravages would be of comparatively small importance. Previous to my last lecture on the defence of London I had some conversation with that brave man Mr. Braidwood, who lost his life, as he had passed it, in the service of humanity. He pointed out in minute detail the certain results of bombardment in the city and commercial depôts. He pointed out warehouse after warehouse filled with the magnificent products of our industry, and from his experience he made it evident that the chief enemy of London is conflagration. Yet with subdivision of labour, by care and with forethought, even this terrible monster may be bridled. On the map crosses are placed to indicate the volunteer forces mustered at the selected alarm posts. At each alarm post I propose to establish a fire brigade to act within a special district. And there is this remarkable circumstance,—the power of fire, as the late Mr. Braidwood explained it, extends its active force to but a trifling distance; embers may be carried any distance by the wind, but sheets of flame do not pass beyond eighty feet. Practically one side of the New Road may be in flames without communicating to the opposite buildings.

Then there is another point with regard to the condition of the inhabitants of the metropolis in any quarter, if invested. The real difficulty in English defensive warfare would be to withdraw the non-combatants, and to supply them with food. It is said it would be utterly impossible to feed

London, which is an assumption to be considered in combination with the safe conduct of the non-combatant. Supposing that London were invested and assaulted on whichever side might be selected, it surely could be no difficulty, with the communications spreading in every direction, with the means of organisation and power to move troops by railway, to remove from the front of attack the whole of the non-combatants. It is nothing new. During the threatened invasion of Napoleon every Lord Lieutenant of maritime counties had distinct instructions as to the removal of non-combatants, food, and stores of all kinds to the interior. If that could be done then, with the insufficient aid of only animal traction, it ought to be more easily effected now with the facilities which railways afford. Pass the non-combatants to the rear, but not as a helpless crowd. Select beforehand the points on which these thousands are to be directed, and there prepare the magazines from which they are to be maintained, until with the retreat of the invading army returns the power of re-occupying their homes.

Then the social disorganisation which waits all such terrible convulsions has been urged as an apology for surrendering the capital. A strong picquet would be under arms at each alarm post; and I do not think it would be difficult for the metropolitan police, supported by strong picquets, to crush any attempt of the dangerous classes to create disturbances. This is not a point on which we need dwell for a moment in apprehension.

Now with regard to the cost: I find my estimate has not met with general concurrence, it being conceived that the land will be much dearer. But in the first place I take the large quantity of 15,000 acres. Those 15,000 acres are not of the valuable land on which the villas which these lines are designed to guard are constructed. The land is generally valuable alone for pasture, and that not of a very high quality. I am aware that some land would be valued at £700 an acre, but I believe the land purchaseable at and less than £100 an acre is so greatly in excess of the more valuable ground that £100 an acre would be the average price. Then it is said the Government always pays largely; now, I know no reason why Government should pay more than an individual. I am confident, if the point were judicially put to juries impanelled to assess the value of land, that they would give an equitable award in accordance with their duty and the fact. Again, it is said that the railways have to pay largely. Now the railways make the ground valuable, but military lines leave the condition of the country unaltered. But in any case I believe the maximum estimate which is given in the report of the Defence Commission, of £179 11*s.* 4*d.* per acre for works, is a far larger sum than would be required for the ground on which the proposed line would be placed.

And so, with your permission and the kindness of those who have heard me, I have briefly given the reasons that have induced me to propose this mode of tactics. I have felt that I was, to a certain extent, perhaps to a great extent, presuming on what might be the province of abler hands, but I felt that, when an English question is submitted, every Englishman is entitled to speak.

I have attached great importance to the power of resistance—direct resistance—afforded by the masses of Volunteers. The Volunteer army of

London at this moment numbers, I believe, 20,000 men. Now, I do not at present regret the comparatively small numbers of the Volunteer force, compared with what might be expected from a large population, because there is a consequent opportunity of more accurate drill. In the 20,000 Volunteers, I see the future officers and non-commissioned officers of the Volunteer army of London. 20,000 properly trained men can soon train 180,000 men if required. And that they would thus labour cannot be doubted. They would feel that their honour was engaged in bringing the force to the highest point of efficiency. Their willingness and devotion to the public service have already received an enthusiastic acknowledgment from their countrymen, which many a bold soldier of the ridge of Delhi and of the trenches of the Crimea would have thought an adequate recompense for all his trials. Therefore, I know what exertions that great body will make. Within the capital lie the means of giving strength and volume to that power. There was a time when London was threatened. Two hundred years have passed away. It was a time of apprehension, and strait, and doubt, especially to the City, which then formed London. For the forces of the King were on the march, and within and around its walls was concentrated the power of the Parliament. The men of London did not hesitate. They threw up entrenchments in Hyde Park, of which the traces may, it is said, be found to this day. They armed in defence of their rights, and abided the shock. As they did then, so would London now.

I have to thank your Royal Highness for the attention with which you have honoured me, and I have to thank those who have heard me. I now leave in their hands the decision of the question, whether or no I am justified in the assertion which I repeat, and which knowledge day by day only confirms, that, considering the circumstances of ground, the organisation of our people, and their spirit of defence, "London is the most defensible capital in Europe."

H. R. H. the Duke of CAMBRIDGE: Ladies and Gentlemen, I am sure you will authorise me in saying a few words in reference to what has fallen from my gallant friend who has just addressed you. It would be impertinent in me if I were to follow him in any of the details into which he has gone in that plan. And not only would it be impertinent, but I think it would be improper in my position, if I were to attempt to offer any opinion which I may have formed so hastily upon what has fallen from him. But I am convinced that you will all agree with me, and you will authorise me to state to him, that we have been much gratified with the interesting and clear statement which he has made of his views as regards this great and important question, a question which requires immense study. It is clear the greatest care and attention have been given in the remarks which have just been offered to us. I, therefore, hope that my gallant friend will forgive me if I do not commit myself in any respect as regards what has now been said: but at the same time he will receive from me the acknowledgment of this company and my own, for the very interesting and valuable lecture which he has given to us, and which I have no doubt many of us will think over for a long time to come in all its various minute and important details.

APPENDIX.

ON THE POLYGONAL SYSTEM.

The most recent works on the polygonal system are those of General Prevost de Vernois, of General Noizet in reply, and of M. Ratheau. Colonel Humfrey has published a valuable treatise on the polygonal system as exemplified at Coblentz.

Ratheau examines the original system of Montalembert, as discussed by Zastrow, Blesson, and Müller, in opposition to Maurice de Sellon and Mangin.

His work (Etudes sur la Fortification Polygonale) is elaborate and instructive.

His design is to show that on works of high finish the polygonal trace is more expensive than the bastioned, but that the defensive power is greatly augmented.

He calculates the space covered by works of construction as nearly equal in a polygonal hexagon of 500 yards, and a bastioned decagon of 360 yards.

But it is admitted, that for the defence of large cities the trace of Cherbourg by Montalembert, slightly modified, is superior to the bastioned trace, if each is furnished with wet ditches. For Ratheau considers the polygonal system loses when the ditches are dry; to compensate which the caponier should join the curtain.

But, on a careful review of the entire argument, I adhere to the polygonal system as proposed for London: on account of the simplicity of the trace, cheapness in works of low finish, perpendicularity of fire, convenience for massing troops, and facility of defence by sortie.

GENERAL REMARKS.

The model* shows the defensive capabilities of London by forts, redoubts, and continuous lines, on an area of 20×14 miles.

The octagon of defence, = 55 miles 944 yards, is traced on lines drawn through Woolwich to Eltham, E.S.E.; Anerley, S.E.; Kingston, S.; Hanwell, W.; Harrow, N.W.; Muswell Hill, N.; Stamford Hill, N.E.; East Ham, E.

Each face of this polygon represents a line of battle, of which the works at the angles give standing flanks and the intermediate works supports.

Nine points for forts on an inner line of defence are indicated on Tele-

* The model referred to was afterwards placed in the International Exhibition of 1862. —Ed.

graph Hill, Forest Hill, Tooting Common, the Ridgeway, in Richmond Park, near Mortlake, near Ealing, on Hanger Hill, and at Whembley, by engineer cairns, = 35 miles, 586 yards, in combination with the N. and E. portions of the exterior sides.

The scale is of six inches to the mile, with vertical augmentation by six to give appreciable relief. But it may be doubted whether the angle of exaggeration does not coincide with the angle of perspective. The ground slopes outwards, at a favourable angle for manœuvre and artillery fire. Sixty-two roads permit the sorties, which an interior railway system facilitates; and streams supply means of inundation, as in the marshes of the Lea and of the Brent.

The forts and permanent works are on the German trace, as best adapted to defence by direct fire, and by sorties from superior capacity.

For it is assumed that the fire of breech-loading ordnance and of volunteer infantry will supply the principal defensive power; wherefore, in order to obtain effective fire, no re-entering angle, or angle of defence, should be less than a right angle.

It is also desirable that the works should be of a simple trace, but formidable, from a wide front of fire. The zone of fire extends to 2,500 yards, giving an elevation of 6°, hence a depressed arch to casemate.

The forts are adapted to prolonged resistance; the redoubts secured from insult; the lines completely swept by flanking fire; and observed, in reverse, by the permanent works.

Arcs of assault to include the external lines of battle are drawn from four centres, or reserve stations: Wormwood-Scrubs, Islington Cattle Market, Peckham New Town, and New Wandsworth.

The slopes of the country are followed, so as to give low angles of depression from ramparts secured from enfilade. The covert way is suppressed, and the glacis slopes from perpendicular counterscarp.

The unit of calculation for construction and armament = 600 yards.

The forts and large redoubts are constructed in brick.

The lines are in earth, with a scarp in concrete; the main ditch, 30 yards wide by 30 feet in depth, has a cunette, and wide ramps for sortie. Mortar batteries are constructed with parados. The lowest command = 22 feet.

The casemated batteries are recessed, so that a rolling projectile would clear in descent the angle included between the terre-plein and the face of the casemate.

The flanks of the bridge-heads on the W. front are traced on sides of a triangle, whose base coincides with the mid-stream line.

The armament is calculated on the regulated war scale, less the difference between the mean service ranges of rifled and smooth-bored guns, multiplied into the relative rapidity of fire from breech-loading and muzzle-loading ordnance. This difference, on equivalent fronts, equals a deduction of $\frac{5}{16}$ from the received proportion.

All guns on ramparts are mounted on garrison carriages, in Haxo casemates, turned in concrete, and stepped in the splay.

Each casemated flank to be supplied with a turn-table, and built on a modification of the Haxo casemate, allowing the gun to traverse through

135°. Lead concrete to be used against injury from cone of blast. Iron gabions for revetment of embrasure.

The fire of casemated flanks grazes the line of defence, the ditch being swept by carronades, with a drop in front.

The re-entering angles in the bastioned lines form *places d'armes* for sortie, under cover of the shoulder angle.

Volunteer alarm-posts, stations for fire-brigades, and police picquets, are marked by crosses.

The lines having been carefully traced in advance of towns and villages, the amount of house property to be purchased is small.

Value is governed by facility of access rather than by distance. 100 yards are allowed in depth for works, and 300 yards additional for a military zone, on which few buildings now exist, and none could hereafter be constructed.

CONSTRUCTION.

Districts.		Length of Faces.	Lines of Manœuvre.	Lines of Artillery.	Lines of Musketry.	Forts.	Redoubts.	Bridge-heads.	Battalions.
		Miles.	Miles.	Yards.	Yards.				
E.S.E.	Woolwich—Eltham	4·29·1	.. ..	13,500	.. ..	1	..	..	..
S.E.	Eltham—Anerley	6·783·2	6·938	7,600	11,900	2	4	..	19
S.	Anerley—Kingston	11·1012·0	11·1012	2,500	13,900	1	8	..	30
W.	Kingston—Hanwell	8·234·2	8·352	6,950	10,000	..	2	6	26
N.W.	Hanwell—Harrow	5·293·1	5·537	2,050	10,800	1	3	..	30
N.	Harrow—Muswell Hill	8·1466·2	8·1466·2	800	23,600	3	8	..	13
N.E.	Muswell Hill — Stamford Hill	3·601·1	3·601·1	3,000	9,000	..	2	..	21
E.	Stamford Hill—E. Ham	7·1642·2	7·1642·2	300	10,400	1	7	..	27
		55·944·2	51·1269·2	23,200	89,600	9	34	6	225

TOTAL.

Forts	9	
Redoubts	34	
Bridge-heads	6	
	—	49
Casemate Batteries	9	
Mortar "	23	

EQUIVALENT FRONTS.

Works	107	
Artillery Lines	50	
	—	157

(Excluding Woolwich.)

COST. (Approximate.)

Land.	Acres.		£
Forts . . .	1,090		
Works . . .	4,935		
Lines . . .	8,896		
	——	14,921	1,492,100

Construction.	£	
Forts . .	450,000	
Works . .	893,875	
C. and M. Batt.	67,000	
Lines Art. .	249,750	
Musketry .	623,200	
	—— . .	2,283,825
Guns, 1842 (excluding Carronades) .		368,400
		4,144,325

ENCEINTE OF PARIS. (Approximate.)

	£	£
Bastioned Fronts . .	94 × 32,000 =	3,000,000

WORKS.

		£	£
First Line . .	25		
Second . .	24		
Third . .	5		
	—	54 × 60,000 =	3,240,000
			6,240,000

(The purchase of land not included.)

ARMAMENT—Guns in Position.

	Forts.	Re-doubts.	Bridge-heads.	Artily. Lines.	Flanks.	Carron-ades.	Case-mates.	Mor-tars.	Total.
E.S.E.	48	..	..	194	..	..	41	48	338
S.E.	72	78	..	96	40	98	..	16	400
S.	20	100	..	34	48	40	..	30	272
W.	..	35	92	92	14	..	..	..	233
N.W.	12	26	..	18	67	69	24	12	228
N.	89	93	..	17	80	35	..	18	332
N.E.	..	15	..	34	32	32	..	24	137
E.	40	92	..	4	40	36	..	..	212
									2152
							For Redoubts		40
									2192

ARMAMENT OF BALAKLAVA LINES, February, 1855.

Length of lines—yards 4,500

Armament—Guns 17
Howitzers 20
— 37

1 gun per 121 yards.

Gunners R.A. 125
M.A. 50
— 175

Garrison. English 2,420
French 450
Turkish 1,310
—— 4,180

One troop of Horse Artillery.

Total.
338
400
272
233
228
332
137
212
2152
40
2192

, 1855.

00

17
20
— 37

175

180

Evening Meeting.

Wednesday, April 30th, 1862.

Major-General the Hon. JAMES LINDSAY, M.P. in the Chair.

BARRACKS.

By Lt.-Col. T. B. Collinson, R.E.,

Instructor of Military Architecture, R.E.E. Chatham.

The Chairman: I have the pleasure of introducing Lt.-Colonel Collinson, R.E., who has been kind enough to come here this evening for the purpose of reading a paper on the subject of barracks. It is a subject he is well qualified to dilate upon. We all know it has become of late years a most important subject. It is only to be regretted that it was not important many years ago, for then our soldiers would have been in a very much better position than they are now. Still it is a subject which is engrossing more of the public attention than formerly, and we know that when public attention is brought to bear upon a question of this sort, the public finances will be brought to bear upon it also.

Lt.-Col. Collinson: The subject of this paper is the plan and arrangement of barracks. The object of it is, without going into details of construction, to endeavour to reduce the requirements in barrack buildings to principles, and to extract therefrom a few general laws for their arrangement, and a few simple plans of buildings applicable to barracks generally.

That certain general principles of arrangement and a certain uniformity of buildings can be attained, must be evident to all officers who have been quartered in permanent camps; and that it will be economical and advantageous to the service to attain both, must be evident to all who have had opportunities of observing the irregularities of the arrangement of our numerous old barracks; and finally, that this is a suitable time for the consideration of such a systematic attempt will appear from the Report of the Sanitary Commission to the Secretary of War last year, in which it is stated, that to provide every soldier with the cubical space recently laid down by the Secretary of State as necessary for his health, will require an additional accommodation of one-third to the barracks in the United Kingdom, or for between 20 and 30,000 men. If, therefore, owing to this cause and to the changes in the disposition of troops consequent on railroads and telegraphs, there is a probability of a considerable alteration to and increase in barracks, a project for reducing the arrangement of them to principles, and for establishing types applicable to the different classes of military buildings, is a fair subject for the discussion of the Royal United Service Institution.

In bringing forward such a proposition, it must be understood that, although I have received the assistance of the office of the Inspector-General of Fortifications, and of other military departments (because the subject forms part of the course of military architecture, of which I have the charge, at the Royal Engineers' School at Chatham), the particular propositions that will appear in the course of the paper must be considered as given on my own authority only, as the expression simply of my own views; and further, that I cannot claim the merit of inventing any new system of barrack-building, for the barracks existing already in the British empire have left no field for an inventor—my office has been that of a curator of a museum, that of arranging the most characteristic and favorable specimens of barracks I can find, and from them and the books of regulations endeavouring to discover a law for their formation.

At the commencement of this subject, the first consideration is, "What is the object of the buildings?" in former times, before the invention of gunpowder, there was no difficulty in answering this question: then all military buildings were designed solely for defensive purposes; the wants and conveniences of the garrison were subservient to those for the defence of the building; but, the ordinary construction of walls being proof against the weapons of the attack, the military architect requiring only for defensive purposes a stout wall with flanks, could arrange it to form part of the cover for the garrison and stores, and thus arose that description of military architecture which we call castellated.

But with the invention of gunpowder arose the necessity of having large fortresses with earthen ramparts and covered escarps, and the consequent necessity of separating the buildings required for the cover of the garrison from those for the purely defensive objects; and the former became more and more assimilated in character to the ordinary buildings of civil life, and now in England we have become so habituated to consider the whole island as one great fortress within which the military buildings may be constructed, with a view solely to economy and health, that the defensive element has been very nearly lost sight of altogether. If, however, we reflect that a large proportion of our army is stationed abroad, in stations selected for purely defensive reasons, and that even in the United Kingdom a considerable proportion of the troops kept in it will from henceforth be in strategetical or at least military positions, it appears reasonable that the defensive element should be considered in treating the question of barracks generally for the whole army.

Indeed, if we could get a literal answer to our question with respect to the military stations in England, it would doubtless be found that almost all of them were originally selected for purely military reasons; and if there is a purely military object in stationing troops in any particular place, the selection of the site, and the arrangement and construction of the buildings, should be chiefly ruled by the same considerations.

There are two other important considerations which must combine with that of defence, in ruling these questions, viz.:

2dly. Administration, or the duties to be performed in the barracks.

3dly. Health.

None of these then can be omitted in the questions of site, arrangement, and construction; it is the problem which the military engineer has to

solve, of fitting his barracks and buildings to the locality, so as to give to each of the three its maximum value possible, giving weight to them in their relative order of importance.

I propose to consider each of them in order; and as a military engineer I naturally consider defence as the main object of barracks, without which there would be no object in having troops at all.

Defence.

For the purposes we have now under consideration, this part of the subject is simple, and will cause little discussion from those concerned in the other two points; for we are not dealing now so much with sites, as with arrangement on a given site. Still, as I wish to apply some principles to the arrangement of a large military station, I must refer to the opinions given in the Report of the Sanitary Commissioners on Barracks and Hospitals to the Secretary of State for War last year (which will be more fully quoted afterwards), that "an unhealthy site leads to a constantly recurring loss of efficiency among the troops from preventible diseases, and this fact ought to weigh forcibly against selection of ground for purely military purposes. What we contend for (they say) is, that all the circumstances and conditions should be weighed together before arriving at a conclusion." But it must be borne in mind that, if defence enters into the question at all, the requirements for it are so imperative that in general a position is fixed absolutely by the nature of the ground. If it is to be considered at all, it must necessarily be the first consideration. In planning the general arrangements of any new military station that is not included in some other line of defence, the first thought of the military engineer must be, how is this station to be defended by the smallest number of men against an attack without artillery? How are the defenders to be supplied with ammunition and provisions, and how are they to keep up their communications with the places representing to them the main body?

The sites being determined, the arrangements for the defence of any particular block of buildings against musketry can be made without material alteration in the plan or construction of the buildings as proposed for their ordinary purposes. There are many instances of defensible barracks in the United Kingdom; sometimes it has been done by enclosing the space with a loopholed and flanked wall, as in the original plan at Preston; sometimes by arranging the buildings themselves to flank each other, or by concentrating the buildings into a compact form, systematically arranged in faces and flanks. By placing any of the buildings, specially strengthened, at the angles of a rectangular block of barracks, the whole could be defended from four points, and the ordinary barrack wall could be arranged so as to form an outer enclosure, or line of defence beyond the buildings themselves.

The efficiency and advantages of the simplest kind of flank defence was well illustrated in the hotel at Newport, in the Rebecca riots, when owing to two bow windows in the front, a few soldiers held in check the rioters, who would otherwise have been in possession of the town.

A fort or castle is not required at every military station, but it seems

only a reasonable answer to the first question, that the buildings should be so arranged that the garrison can turn out and form a line with the least possible delay, and under cover, ready to march wherever they may be required, leaving the smallest possible number of men behind to keep their barracks and stores in perfect security.

Administration.

The next question that the military engineer would naturally ask himself is, "What are the duties to be carried on in this establishment?" for the construction and disposition of the parts of it should evidently be suited to those duties in the most efficient and economical manner; and, as we are dealing with a military body whose efficiency depends in a great measure on organisation, it is the more essential that very careful consideration be given to the arrangement of the dwellings, with the especial view that they shall be in harmony with that organisation. To speak as an engineer, I should say, that the more the buildings fit the machinery of organisation, the less friction will there be in using them.

In order to understand clearly the administrative wants of a military station in the matter of buildings, we must take into our field of view such a section of the army as will contain at least one complete unit of each of the different departments required for its existence. Organised as the British army is, the brigade or district constitutes this one complete self-contained section. A general officer's command in a district or garrison at home or abroad is a specimen of a completely formed articulate military body, consisting of certain internal organs called the staff, and of other external members, called the combatant or regimental force.

These may be briefly described as follows:—

1st. *The Staff.*—1. The General Officer commanding, who is the head and centre of motion.

2. The Adjutant-General and the Quartermaster-General, who may be represented as the mouth and eyes of the general.

3. The Commissary-General, who supplies money and provisions to all the force.

4. The Military Storekeeper, who has charge of ammunition and war stores of all descriptions, excepting provisions.

5. The Commanding Engineer, who is responsible for the efficiency of the defences, and who is the constructor of the force.

6. The Principal Medical Officer, who guards the health of the troops.

7. The Barrack Master, who has charge of all quarters after they are built, and of all furniture, bedding, and utensils connected with them.

8. The Chaplain, the Inspector of Schools, and the Inspector of Musketry, for the moral, intellectual, and physical education of the troops.

9. The Military Train, for transport.

10. The Governor of the Military Prison.

2nd. The *Combatant or Regimental Force,* which are the members for whose service the internal organic staff exists, consists of—

The regiments or battalions of Infantry;
The regiments of Cavalry;
The batteries of Artillery.

If it was a question of putting such a specimen of the body military into cantonments in the field, the regimental force would of course be placed in the foremost line, towards the enemy, and the departments of the staff in secure positions in rear. In a permanent military station, or garrison, supposed to be equally exposed on all sides, and dependent on itself for its own defence, the natural mode of carrying out the same principle, would be to place all the regimental or combatant forces round the exterior or circumference of the station, and all the internal organs, or staff departments, in the interior of it; the former being thus most commodiously placed for defence or offence, and the latter for security and communication.

The office of the general and his two chief staff officers would be in the most central and accessible part of the station; that of the commissary-general, containing the military chest, would be in the most secure situation, and his storehouses, to and from which there would be a regular daily communication for provisions with all parts of the station, would be, next to the general's office, in the most central position; and next to them in importance of centrality, if not before them, would come the barrack-master's office and storehouses; for he has incessant communications with all the regimental force concerning quarters, and furniture, and bedding, and fuel, and light, and water; in short, all those household wants which are daily felt by everybody. He, however, in addition to his central storehouses, must have in each regimental barrack what may be called expense storehouses, for bedding, fuel, and furniture; whereas the store-rooms of the regimental quartermaster, who receives the provisions from the commissariat, should contain only one day's supply.

The most important consideration for the engineer department is facility of access to land and water transport, on account of the heavy and bulky nature of the materials they deal with. Here would be the great workshops of the station, and therefore the barracks of the sappers, who would be chiefly employed in them, should be near the same place; and the commanding engineer's office also.

The military storekeeper should also have access, as far as possible, to land and water transport, as he has to deal with guns, and carriages, and such like heavy articles; his stores being for the most part of very valuable nature, should be placed in a secure position. The principal magazine of gunpowder would of course be placed in a site specially selected for its security from fire and injury, and separated from all other buildings. Expense powder magazines would be required in each regimental barrack.

The hospitals of the army are now so organised that they consist of an assemblage of so many regimental hospitals into one establishment, having each its separate regimental building, in which the sick are treated by their regimental officers; having also special wards for special diseases, and certain staff buildings common to the whole establishment. The regimental part consists of the wards, and rooms for nurses, orderlies, lavatories, &c. The staff buildings include the surgery, dispensary, kitchen, store-rooms, orderlies' rooms, &c. and offices.

At a large military station there should be one such hospital establishment, if a suitable site can be found for it; the selection of which must be ruled solely by sanitary considerations. It is not absolutely necessary,

but very desirable, that the site should be within the general line of defence. If the regimental barracks are so situated that any one of them would be more than one mile from the site of the hospital, that establishment should be divided, and part of it erected on some suitable site especially for such barracks.

The office of the principal medical officer should be at the general hospital.

The barracks of the military train should be situated in the most convenient place for access by carriage roads to all the staff and regimental buildings of the station, as their duties connect them pretty equally with all branches of the service.

It is hardly necessary to mention the other departments of the staff, because they require little more than rooms for their personal offices, excepting the educational and recreation branches, which of late years have been increased and organised to such an extent as to form considerable departments of the staff of the army in themselves. It is convenient, though not, perhaps, strictly correct, to class them together; for their buildings are more interchangeable with each other than with those of other branches, and some are on rather debateable ground between the two. Education may be said to include all chapels, schools, practice-grounds, drill-sheds, and gymnasiums. Recreation may be said to include libraries, reading-rooms, canteens, ball-courts, quoit and skittle grounds.

The school organisation of the army is staff, and not regimental ; the schoolmasters are under the immediate direction of the staff. Therefore, the school establishments of a military station may be collected at one spot, subject only to the proviso, that it is not too far from any one of the regimental barracks ; otherwise, concentration is advantageous for school purposes. The gymnasium of the station, for only one gymnasium regularly organised as a school of exercise would be required at a station, might be at the same spot ; and also the soldiers' library, considering the latter as merely a place for the custody of the books, from which the men could draw them for reading at their own barracks. Drill-sheds being required for regimental purposes only, should be part of the regimental barrack ; and rifle practice ranges must be, of course, at the nearest suitable locality, which should not be more than two miles from the centre of the station.

There does not exist in the British army any systematic instruction of soldiers in industrial trades for the sake of instruction, and the only mode of employing soldiers at such useful trades without incurring an unremunerative expenditure is through the means of different departments of the army which requires artificers, and do now employ civil artificers to carry on certain of their duties. In the Engineer department, and the Store and Barrack and Commissariat departments, and the Military Train, artificers of almost every trade could be effectively and economically employed; but, as part of the school organisation, probably the only crafts that could be effectively introduced are the same which form part of the regimental system—tailors and shoemakers.

The other half of this semi-attached couple which I have unceremoniously joined together, the recreative, is more difficult to deal with on account of the variety of wants included in it, which come under no known military

law. We wish to provide the soldier with healthy recreation, and with what may be called recreative relaxation and social recreation, and such recreation as shall act as a counter attraction to, and substitute for, the low description of public houses and shops which spring up round a military station.

The difficulty is to provide what shall be efficient and economical to be efficient, and at the same time sufficiently accessible to be a real relaxation. Such establishments as reading rooms, where smoking and tea and coffee is provided, and quoit and skittle grounds, and small ball courts, would probably be most effective as part of the regimental barrack, so as to be always available to the soldier by day and night, without leaving his own barracks. They are establishments that require little outlay beyond the furniture of a comfortable room, and a small current expenditure, and could therefore be economically managed in a regiment. But the canteen (which is never a regimental establishment, but always held by a lessee or contractor under the War Office) should be concentrated in one or two places according to the size of the station, otherwise it will not be sufficiently remunerative to enable the lessee to provide such attractions as will counteract the public houses outside. It may be near the library, but not connected with it, because they are two establishments under different management, and, to some extent, in rivalry. The racket court and large ball court, and other quoit, skittle, and cricket grounds would be properly placed near the canteen. Those rooms called day rooms, recently added to some barracks, could be used as regimental reading rooms.

The Regimental Force.

And now, having made this brief analysis of the internal organs of this individual specimen of the military establishments, there remains to be considered the requirements in position and interior arrangements of buildings for the active members of the body, or the infantry, cavalry, and artillery (the engineer barracks having been already provided for).

As this forms the essential part of this paper, I propose to take each of these three branches separately, for the interior arrangement of its buildings, and to consider now only their general distribution in the military station.

For administrative purposes, which we have now under consideration, the organisation of the army is regimental; the regiment or battalion of infantry, the regiment of cavalry, and the brigade of artillery, form the units of the brigade, just as the brigade forms the working unit of the army. The location of the force should be therefore by regiments; each barrack should contain a regiment complete, and nothing more than a regiment, so that the commanding officer of it, who is the person solely responsible to the general for its efficiency, shall be the sole authority within its walls, and each regimental barrack should contain all the establishments required for it, which are not included in any of the staff departments already considered.

The positions of the regimental barracks for the requirements of administration would be much the same as those for defensive purposes,

namely, round the circumference of the staff buildings, on such commanding points enclosing the whole position as cover the ground from barrack to barrack, and have access to good carriage roads both to the centre of it and also to the principal high roads of the neighbourhood; by such an arrangement the different barracks, and such other buildings as the church and military prison, would form a kind of chain of posts round the position, the infantry barracks being placed on the principal commanding points, and the cavalry and artillery being placed with regard to facility of access to the main roads on either flank, so that the whole brigade could move in its regular order of march in any direction with the least delay.

The site of the permanent barracks at Aldershot affords a good study for such an arrangement.

Health.

It is probable that in general the sites for regimental barracks recommended by administrative and defensive considerations would be also found to be the most healthy; but in order that the general requirements of this very important third division of the subject may be fully represented, I cannot do better than quote the opinions of the Sanitary Commission before mentioned, as the latest and best authority upon it.

With respect to selection of site, they say—

The position of a barrack must be primarily determined by military reasons; but wherever there is a choice of position, it need hardly be stated that a healthy country site should be chosen in preference to a town site, that the vicinity of marshes, stagnant water, muddy banks, and sites generally where malaria exists, and produces its usual results among the civil population, should be avoided; that there should be good available water supply, sufficient elevation to ensure good drainage to an accessible outfall; that a porous subsoil should be selected in preference to a retentive one; and that the area of ground should be large enough not only for the healthy disposal of the buildings and for exercise and recreation, but for preventing encroachments of the civil population.

The Regimental Barrack.

Infantry.

The site being settled, what are the requirements in the internal arrangement of the regimental barrack? Those for *Health* should in this case be first mentioned, that they may be borne in mind in considering those for administration and defence. Here again we cannot do better than take the authority of the Sanitary Commission of 1861.

Block Plan.—In barracks, as well as in all buildings where a large number of human beings are to be lodged together, it is most advisable, as a general principle, to place nothing likely to affect injuriously the purity of the air in the same building with the inhabitants. Stables, kitchens, latrines, and baths should therefore be built away from them. The building should be arranged in the simplest manner possible. Squares with closed angles should be, as far as possible, avoided. The great object to be aimed at is to have free external ventilation all round the buildings; in temperate and cold climates to have as much sunlight as possible, and to avoid a purely northern exposure for barrack rooms. One of the simplest and best arrangements for barracks is a single line lying north and south, if possible to allow the sun to shine on both sides of the range every day. Several parallel blocks, at sufficient distance from each other to enable the whole outer wall surface to be freely exposed to the sun during the day, might be

used on some forms of ground. Arrangement in square might also be adopted for large barracks, provided the angles of the square were left open.

***Arrangement of Buildings.*—No part of a barrack, whether for sick or healthy men, should be placed too close to the boundary walls. Latrines, cookhouses, stores, and other similar buildings, can be placed between the barrack and the wall, but the arrangement should be such as not to interfere with its external ventilation.**

Barracks, as well as all populous buildings, are best constructed of only two stories of inhabited rooms. Three stories are not objectionable for healthy people, though objectionable for sick. Four stories should only be resorted to when, from the dimensions or form of the ground, it is absolutely necessary to adopt this number of floors.

Dry stores, staff and regimental rooms for administration, day rooms, libraries, and reading rooms, may be placed without detriment on the ground floor with mess rooms over, when it is necessary to do so. Basements should never be used for barrack rooms, nor indeed for human dwellings; they are always more or less liable to damp, stagnation of air, and deficiency of sunlight, and are well-known nurseries of disease in civil life.

The organisation of a regiment of infantry is similar to that of a brigade. the regimental staff consists of similar members and performs similar functions for the regiment to that of a brigade, and the companies correspond to the battalions. There is the commanding officer, who is the head and centre of the regiment, the adjutant, the paymaster, the quartermaster, the surgeon, and the musketry instructor, and then there are the companies, beyond which the organisation of the army does not virtually extend; the subdivision of a company into squads is for better supervision only, the captain being solely and entirely responsible for the efficiency, clothing, pay, arms, and messing of the whole company. The company therefore is the lowest unit that should be considered in barrack arrangements. It is almost impossible, owing to the frequent alterations in the strength and even establishment of a company in the British army to ensure that certain quarters, however rightly designed, shall be always preserved intact to one company, but the endeavour should be to have such an arrangement that the head quarters of a company shall be as clearly designated in the building as the head quarters of a regiment.

The arrangement of an infantry regimental camp shows the complete requirements for administration and defence, and the French permanent camp of Chalons carries out that arrangement almost completely. In a permanent barrack, having no enemy in front, the officers' quarters and the staff buildings would be more suitably placed in the front line, together and detached from the men on either flank of the line of companies quarters, parallel or at right angles to it, according to the length of parade required. That parade, however the buildings are disposed, should be sufficient to enable the regiment to form in line and to march past in column; for an ordinary regiment of the line about 900 feet by 250 feet is required for this purpose. The parade, to speak nautically, is the quarter-deck of the barracks, and, as long as it is within some kind of boundary, it is better that it should be outside the buildings, which can then be more concentrated for defence.

The staff buildings should contain accommodation for the commanding officer's office, the orderly room, paymaster's office, court-martial room, the quartermaster's office, and store rooms and workshops. For both administration and defence the best position for the whole of these is in the centre of the front line of companies' quarters, sufficiently advanced to distinguish them; the commanding officer's office being in front overlooking

the parade, for this should be the most central and conspicuous building in the barrack; it contains the colours and records of the regiment, and and from it all orders issue.

A synopsis of barrack accommodation was compiled in the office of the Inspector General of Fortifications a few years ago, from authorised plans and opinions of officers of all branches, and, though not an authoritative document, I shall quote it as giving what may be considered as the custom of the service up to this time. It allows only 12 feet by 10 feet for the commanding officer's office, which certainly appears very small.

The orderly room should be next to his office, and should contain space for about 15 persons to write. This synopsis allows 18 feet by 12 feet, which appears small.

The paymaster's office should be about the same size as that of the commanding officer, containing a fire-proof safe for his military chest.

The court-martial room should be about the same size as the orderly room, the synopsis allows 18 feet by 18 feet.

The quartermaster requires a room about 30 feet square to hold the annual clothing of the regiment, the spare stores and baggage and regimental necessaries and kits of absent men, and a room about 20 feet by 15 feet for the daily provisions of the regiment, as received from the commissariat department.

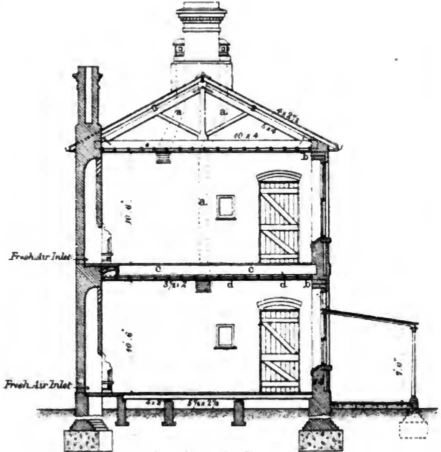
The tailors' and shoemakers' shops of the regiment, which are both under the quartermaster, would together require nearly the same space as the storerooms, and could therefore be suitably placed over them. The armourers' shop, also under the quartermaster, should be in a detached building on account of the fire and noise, and would therefore be suitably placed in a yard behind the staff building. In the same yard could very properly be placed such expense storerooms as the barrack-master required for fuel, bedding, straw, and furniture, and also the fire-engine, which is under his care: they would thus be in the most central position for convenience and saving of labour.

The Companies' Quarters.

The cost, the efficiency, and the convenience of the barrack depend chiefly on the arrangement of the company quarters. The ordinary strength of a company in an infantry regiment may be taken at 3 officers, 4 sergeants, and from 80 to 90 rank and file: but from the latter, for the present consideration, must be deducted the proportion of married men, who by a late order of the Secretary of State are provided with special quarters or receive an allowance of lodging money to find their own quarters; this proportion is 8 per cent., which leaves an average of about 76 men. A proportion of the company sergeants are also allowed to be married, but the system of responsibility in the British army requires that the sergeants should be close to the men, especially the colour and pay sergeants; the company quarter should therefore include 4 small rooms for them, whether married or single. In determining the size of the company quarter, the first consideration is that the rooms should be comfortable. The barrack room is the soldier's home; and, whatever other means of recreation are given him, the place where he sleeps and keeps his things should be his real home. A room of 70 or 80 men would not be com-

COLCHESTER BARRACK.

Plan of Half of One Unit of Infantry Qrs for a Company consisting of 4 Sergeants. and 76 Single Men allowing 600 Cubic Feet to each.

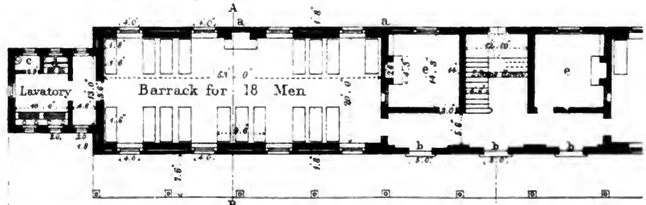


Section A. B.

Scale 5 Feet to One Inch.

Note. a. a. *Are the Foul Air Flues.* b. b. *Louvred Ventilators.*
c. c. *Joists 11 x 2½ - 12 apart.* d. d. *Joists 12½ x 3 - 7 ft apart.*

Half of Front Elevation.



Half of Ground Plan.

Note. a. a. *Fresh Air Inlets* b. b. b. *Sliding Doors.* c. *Night Urinal & W.C.* d. *Foot Baths.* e. e. *Sergeants Rooms.*

SCALE OF 10 5 0 10 20 30 40 50 60 70 FEET

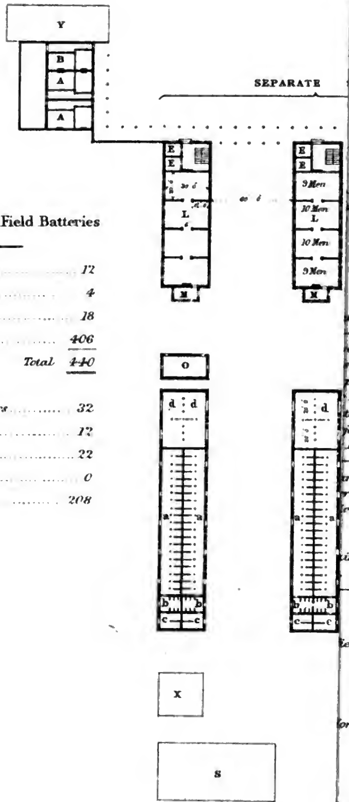
Plate 2

NORMAL

For Two Field Batteries,

Shewing

To face page 549.



Accommodation for 2 Field Batteries

Officers	12
Staff Serjeants	4
Serjeants	18
Rank and File	406
Total	440
Including Married Soldiers	32
Guns	12
Wagons and Carts	22
Horses — Officers	0
— *Troop*	208

S.

. Brigade Field Offr Qrs

ss House.

Office.

ense Store Rooms.

er D E and F.)

of Batteries.

per Division.

Battery.

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P)

nd Drying-ground.

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ield Battery Plan.

orse Battery Plan.

Topl School R.E.E. by
Roeme, Sapper, R.E.
26th June, 1862.

J.R.Jobbins

fortable; it would be noisy, inconvenient of access, and difficult of supervision; on the other hand a small room would be more difficult to ventilate and more costly and also difficult for supervision and cleaning: 18 appears to have been generally adopted as an average number for one room, so that 4 such rooms would constitute an ordinary company quarter. The sanitary commissioners before quoted recommend that the ablution room for the men to wash themselves should be attached to every room, instead of being all in one large room for several companies, which appears to be advantageous, because it promotes cleanliness, and places the room under the exclusive control of the company officers.

With respect to the cookhouse, there are two modes of arranging the cooking in a regiment; 1st, by giving each company a kitchen, which would also serve as a dining room: 2nd, by having one cookhouse for the regiment. There are several advantages in the former system; it corresponds to the company organisation, it keeps the barrack room cleaner and more quiet, and gives each company a sort of day room; but these are counterbalanced by the importance, indeed the necessity, in an army of having an uniform system of cooking, and by the advantages of supervision and cleanliness. The kitchens of a regiment in the field must be concentrated in one or two places, and there should be the same system in barracks as in the field.

The size of a barrack room to hold 18 men is fixed by the regulation of the War Office, giving to every man 600 cubit feet of space. This regution, which is the cause of the great expense of modern barracks, and of the present demand for increased barrack accommodation, has been fixed from the consideration that a man will vitiate and render unfit for respiration that quantity of air in less than an hour. This should be borne in mind by all barrack projectors, because the cost of the men's quarters was from 30 to 40 per cent. of the cost of a complete barrack when the regulation space was 500 cubit feet.

The width of a barrack room allowing a row of beds on each side, and space for a barrack table and forms in the middle, cannot be less than 20 feet. The barrack bedstead is less than 3 feet wide, and the Sanitary Commissioners recommend a passage of 2 feet between each bed; the synopsis allows 4½ feet lineal per bed, which has the advantage of increasing the height of the room and of reducing the floor space. Assuming the latter space, a barrack room to afford 600 cubic feet per man, and allowing 5 feet for a door, and 8 feet for a fireplace, should be about 45 + 20 + 13½ feet. There are two principal modes of arranging the rooms, 1st. Longitudinally, *i.e.* the length of the rooms being parallel to the general line of the building, with the beds along each side wall between the windows: 2nd. Transversely, *i.e.* the length being across the building, and the beds along the party walls and the windows at each end. The former is recommended by the Sanitary Commissioners on the consideration of fresh air, and is exemplified in the new cavalry barrack at Colchester. (Plates III. and IV.).*

* Plate II. shows the plan of what may be called a normal regimental artillery barrack and has been adopted from a project for a barrack by Capt. Belmas of the French Engineers. The artillery barrack only is here given in order to reduce the number of plates; it shows sufficiently the requirements of all three branches. The left half of the plate,

In the Colchester Barrack a unit of one room has been adopted, which is virtually the same as the company unit herein proposed. (Plate III. shows one block of the Colchester Cavalry Barracks, and illustrates the separate system.) Whatever the arrangement, the head quarters and main body of each company should have a distinct house to themselves, with a separate door and separate staircase; and this company unit would therefore include:

4 serjeants' quarters.
76 rank and file quarters, at least.
The company ablution rooms.

Married Soldiers.—In every regiment of 10 companies there are 7 staff serjeants (the hospital serjeant not being included) and 60 to 70 married men to be accommodated. Considering the variable number of married men, and the variable strength of a regiment, it appears reasonable to construct the married quarters on the same plan as the company quarter, with such light partitions that they could readily be converted into men's quarters without altering the main parts of the building. The Sanitary Commissioners recommend a floor space of 150 to 170 feet to be allowed to each family, which is a very fair allowance: at that rate a company quarter would accommodate 20 families; or five would accommodate all the staff serjeants, married men, serjeants' mess, and band-room. Such an addition will add considerably to the per-centage of soldiers' quarters.

The Regimental Barrack.

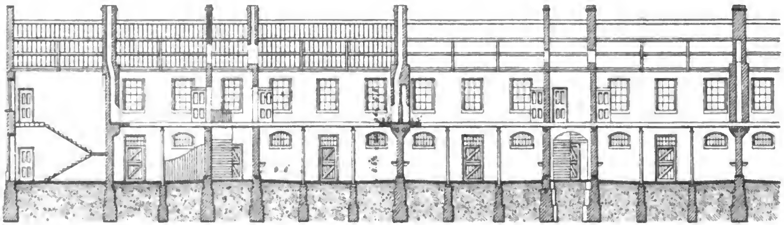
Cavalry.

The organisation of a regiment of cavalry of the line is, as far as barracks are concerned, virtually the same as that of the infantry. There is the same staff under the lieutenant-colonel, with the addition of a riding master and a veterinary surgeon; and there are troops, the captains of which are responsible for their efficiency, clothing, and appointments, and feeding of their men and horses; the squadron formation being one of evolution only in the British cavalry. The number of troops in a regiment, and the establishment of a troop, vary from time to time. For home service the average may be taken at 8 troops, each consisting of 3 officers, 4 serjeants, and 73 rank and file, and 50 troop horses.

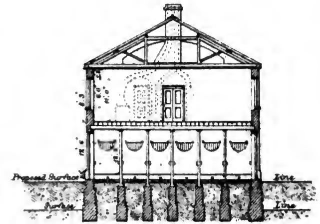
The arrangement of a regimental cavalry camp is similar to that of an infantry regiment; the horses are picketed by troops at right angles to the main front, with the tents in front of each line of troop horses, and the officers' tents in one line in rear. The arrangement of a cavalry barrack should be so far in accordance with this, that men and horses should be quartered by troops, and the men should be as close as possible to the horses; and they should be able to form in line as quickly and conveniently as possible. There are two modes of arranging a cavalry barrack under these conditions: 1st, by putting the men in the same building,

which represents the quarters for one battery of artillery on the separate system, also shows three units of infantry company quarter, each containing the accommodation stated in the text as required for one company. These three buildings are of two stories, each story containing one large room subdivided into four compartments by party walls 7 feet high, the beds being placed along these party walls and the windows in the main walls, of course, and a fireplace at each end.—T. B. C.

HALF PLAN AND HALF SECTION OF CAVALRY QUARTERS, PRESTON BARRACKS.



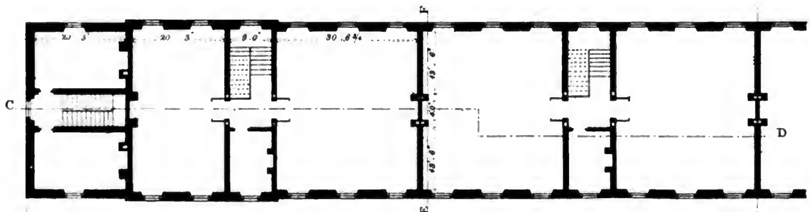
Half Section on the Line C. D.



Transverse Section on the Line E. F.

Table of Scantlings.

Tie Beams 11 × 5 to Camber $2\frac{1}{2}$	
Queen Posts	5 × $3\frac{1}{2}$
Principal Rafter	5 × 8
Braces	4 × 3
Straining Beams	7 × 5
Do. Sill	5 × 3
Ridge Board	8 × 2
Pole Plates	4 × 4
Wall Plates under Joists & Tie Beams	8 × 5 and 8 × 4
Common Rafters	4 × 2
Ceiling Joists	5 × 2
Purlins	8 × 5
Templates to Do	4 × 3
Floor Joists 9 × 24	*Trimmer Joists 1/8 thicker than common Joists for every Joist they are to carry.*
Joists over Passage and Staircases	7 × 24
Ground Floor Joists, Oak	8 × 3
Sleepers to Do. Do	4 × 3
Girders, Fir	10 × 4
Fillets, Ceiling Joists	1 × $1\frac{1}{2}$



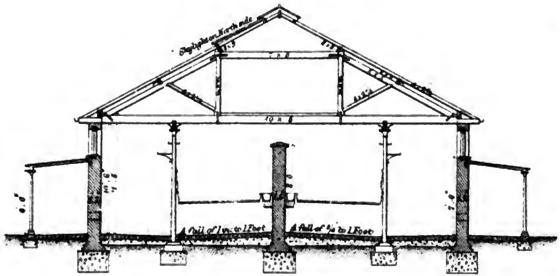
Half Plan of Upper Floor.

J.R. Jobbins

To face page 551.

COLCHESTER BARRACK

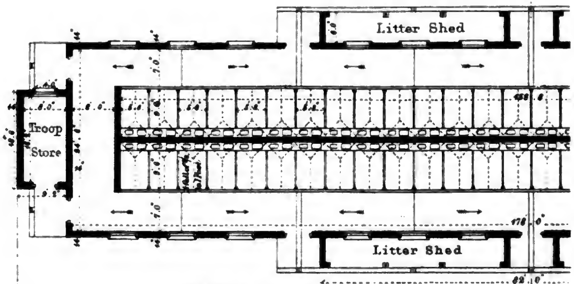
Plan of Half of One Unit of Troop Stable for 56 Horses, allowing 1500 Cubic Feet to each.



Section.

Scale of Feet to Section.

Half of Front Elevation.



Half of Ground Plan.

Scale of Feet to Plan & Elevation.

J.R. Jobbins.

over the horses, which I will call the combined system; 2nd, by adopting the unit of infantry barrack for the men, and using a separate unit of stable; this I will call the separate system.

The Combined System.—The Sanitary Commissioners have expressed a strong opinion against this system. They say:—

> These general principles (the unit of quarter, &c.) are applicable to all barrack-rooms. They involve a change in the manner of constructing barracks, especially those for cavalry, because, to give effect to them, requires the stables to be separated from the men's quarters. We have already pointed out the disadvantages of placing men's rooms over stables. The amount of cubical space per man, according to the new regulation, must be as great in infantry barracks as it is in cavalry barrack rooms over stables. A covered passage could be made from the men's rooms to the stables. The advantages to be derived would be very great as regards men; but it would be even greater as regards horses. After much experience, and attentive consideration of the subject, we do not hesitate to say that it is impossible to ventilate satisfactorily a stable accommodating a large number of horses, if anything beside the roof is interposed between the stable and the outer air; and that it is equally impossible to keep the air in men's rooms over stables pure and free from stable odour.

There are authorities who consider that the men's room being over the stables tends to keep an uniform temperature in the latter, which is one of the chief requirements for the health of horses, and that such rooms are not unhealthy. The system has the advantage of occupying a less total space; but the separate system, in addition to the sanitary advantages, allows of a greater simplicity in barrack buildings, and what is important in our service of greater flexibility. The combined system may, however, sometimes be necessary in sites of limited extent; and, therefore, one-half of the normal cavalry barrack is shown on this system, as adapted to the same French plan of barracks (see Plate II.) In it the accommodation for the men has been taken as the basis of arrangement, to which that for the horses has been fitted, each building containing one troop, men and horses. One of the buildings represents the upper story, where the men are placed, and two the lower stories, where the horses are placed. By taking the men as the basis of the arrangement, of course the upper stories contain the exact number of men, according to their cubical space; the space for the horses is therefore more limited. At Preston barrack there is an example of the combined system, in which the accommodation for the horses has been taken as the basis. Plate I. represents a block of Preston Cavalry barrack, and shows the ground floor occupied by the horses, and the upper floor occupied by the men. The stables run through the building transversely, with 12 horses in each stable, standing against the party walls, tail to tail, with a passage down the centre. This system is therefore not so simple nor so flexible as the separate system, though very compact.

The Separate System.—Colchester barrack is a favorable example of this system. The accommodation for the men is precisely that proposed by the Sanitary Commissioners for infantry, and the horses are placed in a line of large stables in the rear of, and parallel to, the men's quarters, each stable containing 56 stalls; there is a separate stable of special construction for all the officers' horses, and a troop storeroom to each stable. So placed, the stables will occupy a longer front than the men's quarters, and a longer front than the regiment in line. (Plate IV. shows one block of stables of Colchester barrack). In the normal artillery barrack here

shown (Plate II.) one-half is represented on the separate system, the unit of infantry company quarter being used for the men of the troop. Deducting the per-centage of married men, there is on the average about 68 rank and file of troopers to be provided for. The space of the eight men (76 being the infantry number) is there proposed to be allotted to the troop storeroom, which is required for the kits and equipment of absentees of the troop. The unit of troop stable there shown is on the same plan as the Colchester stable, and contains 56 troop stalls, and eight officers' stalls for the seven horses of the troop officers. This number allows six extra troop stalls and one extra troop officer's stall, and has been chosen with regard to the requirements for artillery. The buildings, being placed at right angles to the general line, can be at any convenient intervals, so that they do not exceed altogether the front of the regiment in line, which for an ordinary regiment of eight troops is about 1,000 feet.

With respect to details of construction of stables, I shall only mention, that no decided opinion has been given, that I know of, on the best number of horses to place in one stable, nor of the best position for the saddle racks; and probably horsemen never will be agreed on these points, more than on the size of a stall, or whether horses should be placed head to head, or tail to tail. By placing them head to head in a large stable, as in Colchester barrack, with a division wall 7 feet or 8 feet high down the centre, the advantage of a large stable for ventilation and supervision is obtained, and yet there is a complete division into two, for health and quiet; but then the whole stable must be wider than with the horses tail to tail. In the normal barrack plan, a width of 30 feet is taken, in order to have the same span of roof throughout the barracks.

Our horses appear to require more space than French horses; for the latter people do not allow more than 5 feet for the width of a stall, whereas the synopsis recommends 5½ feet; Colchester is 5 feet 8 inches; and Preston 5 feet 8 inches. The width is generally the same, viz. 30 feet for tail to tail, and 34 feet for head to head.

Staff Buildings.—The staff buildings of a cavalry regiment should be almost the same as those for infantry, and for the same reason situated in the same place. The difference of size, based on the absolute requirements, would be insignificant in cost; the quarter-master's storeroom, which is the largest part, should be as large as that for infantry, because he has the spare equipments of the horses; and the workshops above the storeroom should include the saddlers' shop. The farriers' shop should be in the yard behind, and have space for six smiths' fires; which, as one fire can serve 100 horses, will be ample for the regiment. This would require a space of about 50 feet by 18 feet, and the shoeing shed should be about the same size, having space for 12 horses at once.

If about 60 feet by 30 feet of this yard was covered with a light roof and had a partition down the centre, it would serve for farriers' shop and shoeing shed. The forage barn should be at the back of the same yard, that being the most central position for the men's quarters and stables, which is the great consideration, as the men have to come to it daily for the forage. It must be capable of containing at least 21 days' supply; 14 days' supply being the quantity which the contractor is obliged to have on hand in it. The synopsis allows a space of 35 feet by 18 feet for oats,

65 feet by 18 feet for hay, and 60 feet by 18 feet for straw. A two-storied building 100 feet by 30 feet would be sufficient for this purpose and for the barrack-master's straw store.

There are about 27 staff horses to be stabled, for which (to carry out the principle of separating the staff from the company or troop buildings) a special stable should be provided on the same plan as the others, in the rear of the staff buildings.

A riding school and open riding ground, or *manège*, form part of every regimental cavalry barrack; though probably, where there are several regiments close together, one large riding school would be found more useful than several small ones. The size of a regimental school depends on the average number of horses trained together in one squad or ride, which varies from 12 to 20. A squad of 15 horses, to go through the equitation drill, requires a space of about 150 feet by 50 feet. The *manège* should be in the same proportion and larger. The riding school should be close to the *manège*, and this latter should be on as level a site as possible, in a retired part of the enclosure, surrounded by walls, which need not necessarily be more than 8 feet high.

Regimental Barrack.

Artillery.

The organisation of the Artillery is different from that of the rest of the army, and, being also different and variable in itself, makes it difficult to arrange a normal barrack for them, corresponding to that for the cavalry and infantry. There are three branches of the artillery service: 1st. The Horse Artillery. 2nd. The Field Batteries. 3rd. The Garrison Artillery. It is not, however, necessary for our present purpose to include the latter, as they are only required in fortresses where the barrack accommodation forms part of the plan of the work. And, as the field batteries form by far the largest part of the artillery, the requirements for them should form the basis for their barrack arrangements.

The unit of administration in the British Artillery is the battery of six guns; and the ordinary peace establishment of a field battery is six officers, 11 sergeants, 203 gunners and drivers, 17 carriages (including the six guns), and 104 troop horses (including six for the officers).

The captain of a battery is responsible for the efficiency, equipment, clothing, pay, messing, and forage of the whole battery; he receives the pay, clothing, and equipment direct from the War Department, and the rations and forage direct from the contractor; his command is therefore that of a small regiment, and the barrack of a battery should therefore have an arrangement complete in itself.

The battery is divided into three divisions of two guns each, with a subaltern in command of each, who commands it on parade, and exercises nearly the same administrative functions over it as the captain of a troop or company; the whole force of the battery, men, guns, carriages, and horses, being told off to the three divisions. It is, therefore, further desirable to arrange the barrack accommodation by divisions.

Deducting the officers, and 8 per cent. for married men, there remain 11 sergeants and 187 rank and file to be provided for.

Adopting the separate system, three of the units of infantry company quarter would accommodate the above numbers, leaving the space of 40 men (or about two rooms of 18 men) for the battery store room and collar-makers' and tailors' shops, and a sergeant's room for an orderly room.

Three of the units of troop stable above described would hold all the horses, and (if the stalls were all built expressly with a view to this arrangement), by removing the fitments, would also provide harness rooms and gun sheds and officers' stalls, leaving about 20 spare stalls. Each stable would be occupied by a division, and in each 16 troop stalls would be required for the guns and waggons of the division, and four officers' stalls for the harness. The gun and limber, from muzzle to point of shaft, occupy a space 25 feet long and 7 feet wide; two guns and a waggon could stand in a breadth of 20 feet; and there are two guns and four waggons in a division. A double set of harness (riding and pack), as they are generally hung, occupies about 3 feet of wall lineal, and there are 14 double sets in a division. Thus one unit of barrack and one unit of stable would hold the division, the guns, horses, and harness being under one roof; and three such units of barrack and stable would hold the battery complete, except the farriers' and wheelers' shops.

The Staff Buildings.—One room is required for every battery as an orderly room for the accounts and records; and one room, at least 30 feet by 20 feet, for the quartermaster-sergeant's store room, in which he has to keep the stock of stores and implements, as well as appointments and clothing of the battery. The collar-makers' and tailors' shops may adjoin, and require together about the same space as the store room. The farriers' shop requires space for two fires and a small veterinary surgery, and the wheelers' shop requires about 20 feet by 15 feet; these two shops should be together, and in a position corresponding to that of the farriers' shop in a cavalry regiment.

The forage barn should also be in a position corresponding to that of the cavalry regiment, and upon the same plan, though only about one-third the size.

The plan of a normal artillery barrack (Plate II.) illustrates the requirements for an artillery barrack of two batteries, one-half on the separate system, according to the arrangement above described, and one-half on the combined system, in which one unit of combined troop quarter accommodates the division of a battery, men, guns, horses, and harness, or three units of combined troop quarter accommodate the battery complete, except only farriers' and wheelers' shops.

In the centre of the two batteries would be required a small staff building for the *commanding officer of the brigade*, who, being purely a staff officer, requires accommodation only for his own office and that of his clerks.

The buildings are placed at right angles to the general front, and at 60 feet clear interval, which would allow space for each division to hook in opposite that part of the stable appropriated as a gun-shed. This arrangement most nearly accords with the best plan of an artillery camp, when the guns and carriages are parked in front ready for action, and the men and horses and harness stand by sub-divisions at right angles to the

front, and the officers are in a line in rear of them. The field battery in line occupies a frontage of 400 feet (allowing 19 yards per gun and 19 yards on each flank for wheeling), and about 140 feet deep (on the peace establishment).

Horse Artillery.—The battery of horse artillery has the same organization as the field battery, and the same establishment of men, guns, and carriages, but with six officers' horses and 102 troop horses in addition; therefore, as far as the men are concerned, the same unit of quarter will accommodate them; and, in order to carry out the same principle of quartering by divisions, the unit of troop stable proposed for the cavalry branch should be appropriated entirely to troop horses and harness, by which the three units will hold all the horses and all the harness; and the guns, carriages, and officers' horses should be placed in a stable specially arranged for the purpose, in rear of the staff building, on the site and in the manner proposed for the staff stable in a cavalry regiment.

Officers' Quarters.—The position of the officers' quarters in the regimental barrack having been already discussed, the interior arrangement only remains for consideration; and the chief point that appears desirable to be attained is, that they shall be so simple and uniform as to be applicable to a very small as well as a very large number of officers and to all classes, and to such other military purposes as living-houses are frequently appropriated in our service, in fact, to have a unit of the officers' quarters. The smallest number of officers that we need take into consideration consists of the three officers of a company, the captain and two subalterns; wherever a company is stationed, at least these three officers must be provided for with it, and the simplest and most obvious plan of housing them appears to be in a small house of three floors, having an officer on each floor, so that as many such houses as may be necessary may be put together for a regiment or battery.

The only regulation concerning the sizes of officers' quarters is, that a commanding officer shall have two sitting rooms, two bed rooms, and two servants' rooms; and any other field officer two rooms and one servant's room. The other officers of the army are only entitled, according to the custom of the service, to one room and a share of a servant's room. The synopsis recommends three sizes of rooms—16 feet by 18 feet, 16 feet by 16 feet, and 16 feet by 14 feet. These sizes appear to be, on the whole, large. It is a disadvantage to an officer to have too large a room to furnish and warm and keep clean. The unit shown in the plan of the normal regimental barrack has two rooms on each floor: those on the ground floor are 13 feet by 14 feet and 11 feet by 16 feet for two servants; those on the two upper floors are 18 feet by 13 feet and 11 feet by 16 feet for the captain and two subalterns. The areas of two of these rooms are rather more than those of one room and a-half 16 feet square, as proposed in the synopsis.

One such unit would form a regulation quarter for two field officers, or for the commanding officer; and for the regiment of infantry there would be required 14 such units, for the regiment of cavalry 12, and for the battery of artillery two.

Mess Establishment.—it is more important, considering the system of our service, to have a good mess establishment than to enlarge the

officers' quarters; for it is, or it should be, the place of common resort and meeting of the officers at all times; it should contain a dining-room large enough to dine 50 persons occasionally, and 30 daily; 45 feet by 25 feet is sufficient for this purpose: too large a room could not be made comfortable, and would defeat its object. A comfortable ante-room, where the officers can sit during the day and read papers and periodicals, forms a very important part of the establishment; a long room about 25 feet by 15 feet would be most convenient for it. The establishment should also include kitchen, store-rooms, messman's rooms, forming a distinct branch from the cellars and pantry and butler's room. Altogether the mess establishment is one of so much importance, and so special in its requirements, that it is impossible to include it in any general classification of buildings; it should form a complete building standing by itself, like the hall of a college, and would, if well designed in this manner, not only be more useful, but more ornamental, than if merely fitted into a general block of officers' quarters.

General Remarks.

The subject and object of this paper may therefore be briefly recapitulated to be, "The arrangement and construction of barracks, with a view to lay down some general principles for the arrangement of, and to determine a few simple forms of construction applicable to, all barrack buildings."

The principles of arrangement proposed are based on the three great considerations ruling the whole question, Defence, Administration, and Health; and, while allowing that the perfectness of any one of these three will not compensate for a serious deficiency in any one of the others, I have simply sought to point out some of the necessary requirements of each, believing that in most cases a due consideration of the values of these respective requirements will produce a more harmonious result than would at first be supposed, and that it is at least the only true way of treating the question.

The forms of buildings which I arrive at from these considerations as most simple and generally applicable are the following:

1. *The unit of company quarter*, which, without material alteration, is applicable to infantry, cavalry, and artillery, and to variable numbers, and to married soldiers' quarters, and includes all the purely company requirements.

2. *The unit of stable*, which, without material alteration, is applicable to a troop of cavalry or a battery of artillery, and includes the whole of the horses and appointments, officers and troop, and guns and carriages of a troop or divisions of a battery.

3. *The unit of officers' quarter*, applicable, without any alteration, to officers of all ranks, and to the proportions of each rank in a regiment or to one company, and applicable also to offices.

4. *The unit of storehouse*, or rather normal storehouse, applicable to all stores, regimental or departmental, quartermaster's, barrack, commissariat, or military storekeepers.

The above include all the principal military buildings, which are thus classed into four groups,—barrack, stalls, officers' quarter, and storehouse; of the remaining buildings of a military station, such as the chapel, cook-

house, washhouse, messhouse, schoolhouse, canteen, library, reading or day room, gymnasium, ball-court, prison, it appears hardly possible to classify any two together, either on account of their special requirements or from the uncertainty of the demand for them. The hospitals also form a special group of themselves. But in any or in all military buildings it would be advantageous to have as far as possible only one span of roof, for facility both of construction and repair, and of alteration and re-appropriation.

I think it will be generally allowed, that, in a variable service such as the British army has to perform, every discussion upon military buildings that tends to produce simplicity, uniformity, and flexibility, will also tend to the security, efficiency, and health of the army generally.

The Chairman: I think Colonel Collinson has given us a most useful and practical paper. He has reduced a very complicated and difficult question into a practical form, one which must be extremely conducive to the three objects which he has pointed out: the first, capability of defence; the second, sanitary conditions; and the third, the general comfort of the soldier.

It is an extremely agreeable thing to me, when I look back for about eight years, to find this question so taken up by an officer of Colonel Collinson's standing, and also to see the way in which it has been taken up in recent times by the War Department. The whole of the improvements in barrack accommodation are limited to a period of eight years. They were begun in the year 1854, and they were begun by the present Lord Dalhousie, then Lord Panmure, Secretary-at-War at that time. He appointed a Committee, upon which I had the honour to serve in conjunction with my friend Major White. That Committee was appointed in consequence of the constant observations made in the House of Commons in regard to the deficiency of barrack accommodation, and also in consequence of the frequent representations which were made by various commanding officers to the Horse Guards. Lord Panmure was the first person to move in it. Although I believe that Committee did very great good in pointing out the evils which were attendant upon the barrack accommodation then in existence, yet I am sorry to say the Committee did not accomplish much more, for at that time the feeling in favour of the British soldier had not risen to that fever-heat to which it rose two years afterwards in consequence of the Crimean war. The feeling in favour of the soldier then rose to such an extent, that I believe you could have got any amount of money expended for his benefit. From that time to the present, improvements have been effected which have been most beneficial to him.

You cannot compare the position of the British army with the position of any other army in the world. It stands entirely by itself. Take the French. The Frenchman must be a soldier whether he likes it or not; he has not any option. He can pay a large sum for a substitute, but, as a general rule, he has not got the option whether he will serve or not. And, when enlisted, they give him hardly any pay at all. Everything is found for him, and he must stay in the army until he has fulfilled his seven years' service.

The British soldier on the contrary is a free agent before he enlists.

You cannot compel him to enlist. You give him inducements to do so, but he rarely enlists because he has an affection for the military service. Perhaps he does it in consequence of some scrape he has got into in his village, or because he wishes to join some comrade; rarely in consequence of any great wish to lead a military life. Therefore, our great object has ever been, when we have got him, to make him comfortable as soon as he becomes a soldier. Perhaps at the present moment we are not able to do that to the full extent, but at any rate he is in an incomparably better position than he was eight years ago, and in an infinitely better position than he was when I first entered the service. One of the first things done, has been to take spirits out of his way. Formerly the soldier had nothing to do but to walk out of the barrack room into the spirit shop. There were schools, but schools of an inferior character. They have been very much improved, but barrack building has to be found for these. Libraries are only a recent creation, of perhaps twenty years; barrack building must be found for them. Formerly eighteen or twenty men were crammed into a room with only two or three hundred cubic feet of air, now they are to have six hundred; increased barrack building has to be found for this. So I might go through a long catalogue of improvements which are being made, all tending to the advantage of the soldier, and all consequent I believe upon the movements which have been made, particularly by the officers. I quite acknowledge that these improvements have been carried out by civilians, but those civilians have been prominent men at the head of public departments, without whom we, as soldiers, never could have carried them out. Therefore, I do not mean to deprive them of the full credit of having more than met us half way, and of having done our work for us, because all we could do was to point out the deficiencies which existed, and, having pointed them out, to take advantage of the state of public feeling which gave the opportunity for benefiting the great military branch of the public service.

In offering to Colonel Collinson our thanks for the paper he has read, I can only say that I hope his labours will be conducive to the good of the army.

Evening Meeting.

Monday, March 17th, 1862.

W. STIRLING LACON, Esq., Member of Council, in the Chair.

THE WAR IN NEW ZEALAND.

By Captain Pasley, R.E.

PART I.

The Chairman: I have great pleasure in introducing Captain Pasley of the Royal Engineers, who is about to read a paper upon the War in New Zealand. Captain Pasley served in New Zealand during the war, and was wounded in one of the actions.

Captain Pasley: Mr. Chairman, Ladies, and Gentlemen,—In order to make the remarks which I have to offer upon the war which has recently taken place in New Zealand intelligible to those amongst you who are not well acquainted with that colony, it will be necessary to give in as few words as possible a sketch of the previous history of the country.

New Zealand consists of two large and a number of smaller islands. The northern island, which contains nearly the whole of the aboriginal or Maori race, is considerably larger than Ireland. The other large island is about the size of England and Wales. The first European navigator who as far as we are aware ever visited New Zealand, was Tasman, who touched there in 1642. Captain Cook, who visited the islands in 1769, left behind him a permanent record of his presence, in the shape of pigs and potatoes, then for the first time introduced into the country. These gifts were of the greatest value to the people of a country in which indigenous animals and edible vegetables were very scarce. For many years subsequently to Captain Cook's voyage no attention was paid to the islands, but towards the close of the last century New Zealand began to attract notice in England, America, and Australia, as a favourable station for whaling. A large number of vessels was sent from those countries to cruise about New Zealand in search of whales, and depôts of stores and provisions were established on the coast, the most important of which was Kororareka, in the Bay of Islands.

The natives gladly welcomed these settlers, who in the course of trade supplied them with many things, the value of which they readily learnt to appreciate. In all their dealings they showed an aptitude for improvement and civilisation which has been rarely observed among savage tribes. They cared nothing for coloured beads and trinkets, but iron in every shape found a ready sale amongst them. Blankets and tobacco were also great articles of trade, and soon became almost necessaries of life to them. Constant intercourse with Europeans soon created in the minds of the

more enterprising of the Maories a desire to see foreign countries, and in 1820, Hongi, the principal Chief of the Ngapuhi tribe, made a voyage to England, where he was received with much honour, and introduced to King George IV. Up to this period the Maories had been entirely unprovided with fire-arms, but Hongi, on his return to New Zealand, procured 300 muskets, with which, having armed a portion of his followers, he commenced a career of war and conquest which spread desolation over the country for several years. His contact with civilisation in England does not appear to have done much towards refining his tastes, for, not content with slaughtering his enemies, he cooked and ate as many of them as he could. Traditions differ very much with regard to the origin of cannibalism in New Zealand, but it is supposed to have been first practised as an act of vengeance. There does not seem to be any reason to suppose that the Maories ever devoured human flesh merely for the purpose of satisfying their hunger. The practice was always connected in their minds with the idea of insult, triumph, or revenge. No Maori could offer a more deadly affront to another than to tell him that his father had been eaten. After every battle the prisoners were triumphantly devoured. Thus, war promoted cannibalism, and cannibalism promoted war.

The first result of Hongi's wars was a great demand among the Maories for fire-arms, the possession of which had become essential to the safety of each tribe. This demand gave a great stimulus to trade, and consequently to agriculture and other industrial pursuits. From this again arose a desire and demand for other European manufactures, such as clothing, cooking utensils, and agricultural implements. Notwithstanding these advances towards civilisation, petty wars and feuds raged for many years more violently than ever among the various tribes, to whom the possession of new and more formidable means of destruction appeared to have imparted a fresh desire for blood.

In the meantime the European settlers at various points on the sea-coast had been rapidly increasing in numbers. In 1838 the population of Kororareka amounted to not less than 1,000 souls, chiefly whalers, sealers, runaway sailors, and escaped convicts. These persons were under no recognised or lawful government whatever. The native chiefs did not wish or attempt to exercise any control over them, and no civilised power had as yet claimed any sovereignty over the island. The state of anarchy and lawlessness into which the settlement consequently fell soon became intolerable to the inhabitants themselves, who attempted to put a check upon it by the establishment of an institution somewhat similar to the famous Vigilance Committees of the United States.

In 1839 immigrants of a different character began to arrive, under the auspices of the New Zealand Company, by whom systematic colonization on a great scale was attempted.

Colonel Wakefield, the leader of the expedition, purchased an immense territory from the natives, on payment of goods valued at about 9,000*l.* It appears very doubtful, however, whether the natives understood the real nature of the bargain they were making, or that they ever intended to part with the fee-simple of the land. It had been an immemorial custom among them for tribes, families, or individuals, to make over land to others for temporary purposes, but the right of resumption was always

reserved, and they probably had no idea of the real nature of the claim which the agent of the New Zealand Company was endeavouring to establish upon them. The formation of the New Zealand Company's settlement at Port Nicholson, together with the scandal caused by the lawlessness of the people of Kororareka and other whaling stations, at length compelled the British Government very reluctantly to interfere, and in 1840 Captain Hobson was sent to the Bay of Islands, as first Governor of New Zealand.

In the same year the well-known treaty of Waitangi, by which the great majority of the Maori chiefs ceded to Her Majesty the sovereignty of the islands, was concluded. One of Governor Hobson's first acts was the issue of a proclamation declaring that all future purchases of land from the natives, without the intervention of the Crown, should be illegal, and that the validity of all purchases already effected should be investigated, and Crown grants issued for such as might be proved to have been obtained for fair consideration.

The result of the investigation was that the great majority of Colonel Wakefield's purchases were annulled.

In the mean time a revolution of another kind had been going on in the country. The first missionaries of the Church of England arrived in the country in 1814, under a promise of protection from the great chief Hongi, a promise which, although not himself a convert, he faithfully kept.

They were followed by Wesleyan missionaries in 1822, and by Roman Catholics in 1838. The result of their labours has been very remarkable. I believe that at the present day at least three-fourths of the Maori race are baptized Christians, and professing members of one or other of these three denominations, and the great majority of the remainder can scarcely be called heathens, as, although not baptized, most of them attend church and school. Slavery and cannibalism have disappeared from the land as Christianity has taken root among the people. The eminently practical character of the native mind, which was evinced in the first instance by their preference for iron over the baubles which generally charm savages, had indirectly an important influence on the promotion of Christianity. The missionaries established not only churches, but schools, where children and adults were taught to read aud write in their native tongue. The Maories at once appreciated the immense value of the art of writing, and were thus induced in large numbers to attend the schools, where they were also instructed in the truths of religion. They were thus gradually converted to Christianity, and, as far as it is possible to judge from outward appearances, they seem to be quite as good Christians as the average of Europeans.

It was estimated a few years ago that one-half of the native population of New Zealand belonged to the Church of England, one-fourth to the Wesleyan and Roman Catholic communions, and one-fourth unbaptized, although not necessarily or generally heathens.

At the period of the establishment of the British Government in New Zealand the northern tribes carried on a considerable trade, not only with the settlers of Kororareka, but with the Australian colonies, in which there was a great demand for Hokianga timber. Between 1840 and 1844 the prosperity and wealth of these tribes were greatly diminished owing to various causes, of which the most important were the cessation of the

demand for timber in Australia, the removal of the seat of government from Kororareka to Auckland, and the establishment of customs duties, which interfered with the irregular but profitable trade previously carried on.

A strong dislike to the British Government consequently sprang up in the minds of many of the natives.

Heke, a Ngapuhi chief, who owing to his marriage with the daughter of Hongi had become one of the most influential men in his tribe, took advantage of this feeling, and persuaded a large number of the people that their losses were owing to British supremacy alone. As a practical illustration of this opinion, he and his followers cut down and burnt the flag-staff at Kororareka. He was soon afterwards persuaded to offer an apology to the Government, and the flag-staff was re-erected, but again destroyed by Heke, who appareutly attached some mysterious importance to that symbol of sovereignty. A new flag-staff sheathed with iron was then put up and placed under the protection of a detachment of troops. A small body of seamen, with a gun from H. M. ship "Hazard," were also stationed near it.

In March 1845 Heke attacked the town, of which he obtained possession after a skirmish, which resulted in the embarkation of all the inhabitants and the destruction of the town by fire.

Nothing like a savage or bloodthirsty disposition was evinced by the Maories on this occasion. On the contrary they restored uninjured to their parents a number of children who had been left behind in the hurry of the flight.

Reinforcements having arrived from Sydney, a force was despatched from Auckland to the Bay of Islands on the 3rd of April under the command of Colonel Hulme. It was ascertained that Heke had established himself at a pa called Okaihau, 18 miles inland. The British force consisted of about 400 men, and was joined by an equal number of native allies under Waka Nene another Ngapuhi chief, who has always to this day proved himself a firm friend of the colonists. The expedition carried a few rockets but no guns. The weather being exceedingly unfavourable, and the troops having to carry their own provisions as well as ammunition, four days were consumed in making their way to the pa.

So little was known at that period of the character of these peculiar works of defence, that Colonel Hulme contemplated taking the pa by assault without having previously effected a breach, but he wisely allowed himself to be dissuaded from making the attempt by Waka Nene, who urged him not to sacrifice his men in a mad and impossible enterprise.

The Maories, emboldened by the hesitation of the attack, made a sortie, but were at once repulsed at the point of the bayonet by the 58th Regiment and the Marines. Colonel Hulme, seeing clearly that without artillery he had no chance of success, marched back to the coast and re-embarked his troops, having lost during the operations 14 killed and 39 wounded.

Experience having now shown that the employment of artillery was necessary for the reduction of a strong pa, a second expedition was fitted out for the attack of a new pa which Heke had built at Oheawai, 7 miles inland from Waimate. The force consisted of 630 troops, seamen, &c., with 6 guns, under the command of Colonel Despard, and 250 Maori

allies. The garrison of the pa was estimated at 250 men. The expedition arrived at Oheawai on the evening of the 23rd June, and on the following morning the guns commenced firing on the pa without result. Afterwards a thirty-two pounder was brought up, the fire of which produced so much effect upon the stockade, as to induce Colonel Despard (in opposition to the opinion of Captain Marlow, R.E., who did not consider the breach practicable) to risk an assault. A storming party was therefore told off, consisting of 200 soldiers, seamen, and volunteers, with hatchets, ropes, and ladders. The attempt was most gallantly made, but in a few minutes the troops were compelled to retire, leaving one-half their number killed or wounded at the foot of the stockade.

The enemy, safely esconced in their rifle pits, watched with mingled feelings of admiration and compassion the steady advance of the storming party to certain destruction, whilst our native allies made no secret of the indignation they felt at the useless sacrifice of the lives of so many brave men.

For several days subsequently, no movement took place on either side. On the 9th of July, fire was again opened on the pa, which on the 11th was discovered to have been abandoned by the enemy. On the 14th the troops returned to Waimate.

Both parties claimed the victory, and both with some appearance of reason. The troops claimed it on the ground that they had compelled the enemy to evacuate a strong position. The Maories claimed it, because, being opposed to a number far greater than their own, they had lost but few men, and killed and wounded a great number of their opponents. Such a result in their eyes constitutes a victory, and when we consider the rapidity and facility with which they are able to erect their pas, and the abundance of strong and commanding positions throughout their country, which makes the loss of a pa of very trifling importance to them, it must be acknowledged that they had the best of the argument.

An expedition on a larger scale was dispatched a few months afterwards against Ruapekapeka, a larger and stronger pa than either of those which had been previously attacked.

It was situated about sixteen miles inland from Kororareka, and contained a garrison of about 500 men under Kawiti, a friend and ally of Heke. The expedition consisted of 1,110 Europeans (including 280 officers and men of the navy) and 450 natives, with three 32-pounders, one 18-pounder, a few field guns, and some rockets. They arrived in front of the pa on the 31st of December. On the 2nd of January, 1846, the enemy made a sortie, which was repulsed by the friendly natives. On the 10th of January the guns, having been placed in position, opened fire. They fired all day on the pa, and succeeded in making two small breaches in the outer stockade. The following day being Sunday, the enemy, expecting a suspension of hostilities on that day, retired to the rear of the pa to cook their food and to carry on their devotions. Some of the friendly natives having crept up to the stockade and ascertained that it was deserted, beckoned to the troops to advance. A party of the 58th and some sailors at once entered the pa and established themselves there. The enemy, as soon as they became aware of the unexpected entrance of the troops into the pa, made gallant and repeated attempts to dislodge

them, but in vain. Reinforcements poured in and the Maories were compelled to retreat.*

The natives were now beginning to get tired of the war, which materially interfered with their comforts by stopping their supplies of tobacco, blankets, and other articles, to which they had become so much accustomed as to be hardly able to dispense with them.

Heke's predictions of the renewed prosperity which was to be the result of the war were so far from being fulfilled, that the poverty and misery of the natives increased every day.

Heke and Kawiti consequently soon found themselves almost without followers, and were compelled to sue for peace, which they readily obtained, with a full amnesty from the Governor.

In the same year hostilities broke out at Wellington (Port Nicholson). After several skirmishes, in which the natives were generally the assailants, they were forced by starvation to retire from the district. They removed to Wanganui, and succeeded in the following year in exciting the natives of that district to make war against the Europeans.

On the 19th May, 1847, about 600 Maories attacked the town of Wanganui, where 170 soldiers were stationed in small stockades. A heavy fire was kept up on both sides during the day. In the night the enemy plundered the town and departed. Hostilities were carried on during two months with varying fortune, and on the 23rd July the enemy sent a flag of truce and announced that they were now for peace, " being satisfied with the number of soldiers slain."

The effect produced upon the minds of the Maories by these hostilities was highly gratifying to their self-love. They were, it is true, profoundly impressed by the magnitude of the resources of England, as evinced by the constant stream of reinforcements which poured into the country, owing to which the available number of troops was, notwithstanding their losses, continually on the increase, and they felt the hopelessness of final victory in a contest with a power which became stronger after every disaster. Nevertheless, the ill-success which had attended most of the military operations led them to think themselves very superior to the troops, both in military skill and in personal prowess.

They acknowledged, indeed, that the superior arms and discipline of the troops rendered them very formidable in the open country; but they were in the habit of boasting, that, whenever war might break out again, they would draw the soldiers into the forest, where they would be able to do what they liked with them. Such being their opinion, it is not surprising that many of their young men should have been eager to take advantage of any opportunity of enjoying the excitement and gaining the honour which they confidently expected to follow a collision with the troops.

Although the peace was not actually again broken between the two

* The labour and hardships endured by the troops in advancing and retreating even a very few miles through the forest were excessive, and the cheerfulness, patience, and fortitude with which they were borne, beyond all praise. Had the enemy been somewhat more numerous, and as energetic as the present generation of Maories have proved themselves to be, these expeditions would, in all probability, have shared the fate of that of General Braddock in North America. Perhaps their unmolested retreat may have been due to the presence of the native allies, who, although they did not overexert themselves either in working or fighting, were invaluable as guides and scouts.

races until the year 1860, signs of coming discord were visible as far back as 1854, in which year some of the chiefs of the Waikato tribe, the most powerful and warlike in the country, alarmed at the increasing numbers and power of the colonists, conceived the project of setting up a king of their own; their principal object being to put a check upon colonization, by preventing the further alienation of land. The history of this movement and its connection with the war which has recently taken place at Taranaki are clearly and succinctly described in the following extract from a memorandum drawn up by the minister for native affairs at Auckland, in April, 1860.

That the present crisis in the affairs of New Zealand may be properly understood, it is in the first place requisite to give some account of the views and intentions of the native agitators known in the colony as the Maori or Waikato King party. The contest in Taranaki between the British Government and the chief Wiremu Kingi and his followers derives all its importance from its connection with this movement, for without the sympathy and expected support of the Waikato league the Taranaki natives would never have ventured upon armed resistance to the British Government.

The first proposal for the erection of a separate native state under the Waikato chief Te Whero Whero (now generally called Potatau) seems to have been made as far back as 1854. There was at first considerable diversity of opinion amongst the promoters of the movement, and great consequent uncertainty as to its precise objects. Many well-disposed natives seem to have joined in it without any thought of disaffection towards the British Government, and purely, or principally, with a view to establish some more powerful control over the disorders of their race than the Colonial Government has found it possible to attempt. But there are others whose objects have been, from the beginning, less loyal. These men have viewed with extreme jealousy the extension of the settled territory and the increase of the European population. Various influences have combined to augment the effect on their minds of this natural feeling. The lower class of settlers, sometimes wantonly, sometimes under provocation, have held out threats of a coming time when the whole race will be reduced to a servile condition. Of late, a degraded portion of the newspaper press has teemed with menaces of this kind, and with scurrilous abuse of the natives, and all who take an interest in their welfare. False notions respecting the purposes of the British authorities have been industriously spread by Europeans inimical to the Government, and whose traitorous counsels enable them to maintain a lucrative influence over their credulous native clients; and there may have been some few honest friends of the Maories, who, looking only to the better side of the agitation, have given countenance to a movement which, in their opinion, promised to promote the establishment of law and order, and the advance of civilization, and to afford a beneficial stimulus to the languishing energy of the Maori people.

The Government at one time entertained a hope—a hope now deferred, but not abandoned—that the good elements in the King movement might gain the ascendancy, and become the means of raising the native population in the social scale. It must, however, be admitted that the agitation has of late assumed a most dangerous phase.

The two objects of the league may now be affirmed to be, first, the subversion of the Queen's sovereignty over the northern island of New Zealand, and, secondly, the prohibition of all further alienation of territory to the Crown.

As regards the first object, the more advanced partisans of the Maori king now distinctly declare that the Queen of England may, for aught they know, be a great sovereign in her own country, but that here, in New Zealand, she shall become subordinate to their native monarch, from whom the British Governor shall take his instructions. The utmost conceded to the Queen is an equal standing with King Potatau.

The absolute prohibition of further land sales is a necessary part of the new policy; for it is plainly seen that, unless the further colonisation of the country can be put a stop to, the Europeans will shortly outnumber the natives even in the northern provinces.

The general sentiment of the New Zealanders with respect to their territorial possessions entirely harmonises with the views of the king-makers. The Maori feels keenly the parting with his rights over the lands of his ancestors. The expressive words of the deeds of cession declare that under the bright sun of the day of sale he has wept over and bidden adieu to the territory which he cedes to the Queen. It is in vain to

assure him that the laud remains open to him upon the same terms as to the European settler. He cannot see the matter in this light. The soil, with all its memories and the dignity conferred by its possession, have passed over to the stranger; and in its place he has acquired only perishable goods, or money which is speedily dissipated. The land-holding policy of the King party is popular, because it secures to every native the occupation, in savage independence, of extensive tracts of wild land.

When the first emigrant ships arrived at Port Nicholson, and landed their hundreds of colonists, the natives are said to have wept at the sight. They had been told, but had not believed, that the foreigners were coming to settle in great numbers upon the land which the agent of the colonising Company had just acquired. They had not realised to themselves that their country was about to be occupied by a civilised race in such force as to be able to hold its ground in spite of native resistance. The New Zealanders had always been fond of having amongst them a few Europeans dependent on their goodwill, but they love to remain masters. It is the notion of the King party that the settlers in New Zealand should be placed much on the same footing as the European squatter in a native village, whose knowledge and mechanical skill procure for him a certain amount of respect and influence, but whose homestead is held on sufferance, and who is obliged to comport himself accordingly. "Send away the Governor and the soldiers," they say, "and we will take care of the Pakehas."

The old chief, Te Whero Whero, who has been a firm ally of the British Government, has been removed by his relatives of the new faction from his late residence at Mangere near Auckland to a place called Ngaruawahia, at the confluence of the Waikato with its principal feeder the Waipa. There his supporters have established the old man (who seems to lend himself unwillingly to the farce) in a kind of regal state. The deputation despatched from Taranaki to solicit support for W. Kingi were clothed for the occasion in a uniform dress. They approached in military order. At a given signal all fell on their knees, whilst some one in a loud voice recited the text "Love the Brotherhood. Fear God. Honour the King!" After the interview the deputation retired, facing towards the royal presence. They appear to have been well drilled in this ceremonial.

The absurdity of these pretensions does not render them less dangerous. Unfortunately they are supported in the minds of the natives by an overweening opinion of their own warlike skill and resources. It must be confessed that the imperfect success of military operations in New Zealand has given some countenance to the natives' fixed opinion of their own superiority. In the debates of the Maori council at Ngaruawahia, the experience of the wars against Heki and Rangihaeata, and of the Wanganui war, are constantly referred to as showing how little is to be feared from the prowess and the boasted warlike appliances of the Pakeha.

As regards the further alienation of territory, the received interpretation of the treaty of Waitangi recognises rights in the native proprietor which must be respected, however inconvenient those rights may prove; but it would not be politic, or safe, or right, to submit to the attempted usurpation of a power of obstructing the settlement of the country which the admitted interpretation will not warrant. The treaty secures to the native proprietor the right to part with to the Crown, or to retain for himself, lands which are his own. The King party would assert a national property in or sovereign right over the remaining native territory, and are ready to support all opposition to land sales, without nice inquiry respecting, and even without reference to, the merits of each particular case. In this they infringe at once upon the rights of the Crown and of the native proprietor.

It is by no means meant to assert that all who have joined or who favour the party of the Maori King propose to themselves ends so dangerous and unjustifiable. Potatau himself is probably sincerely averse to any proceedings hostile to the Government. It is, however, uncertain how far he may have power to restrain his people, and it is undeniable that sentiments quite as strong as those above described are freely expressed throughout the districts south of Auckland, and may be expected to shape the action of a large part of the powerful tribes of Waikato.

Such then is the party to whom William King of Waitara is looking for support, and, it is to be feared, with some prospect of success; and it now becomes necessary to give some explanation of the origin of the present disturbances at Taranaki.

The settlement of New Plymouth was founded in 1841 by the Plymouth Company of New Zealand, which subsequently merged in the New Zealand Company. There were at that time scarcely any natives in the district. Some had fled southward to Cook's Straits, to avoid the invading Waikatos. Many others, who had been captured on the

storming of the Ngatiawa stronghold Pukerangiora, still remained slaves in the Waikato country. The New Zealand Company's agent had purchased of the resident natives, with the assent of some of their relatives at Port Nicholson and Queen Charlotte's Sound, a tract of country extending from the Sugar Loaf Islands to a place called Taniwa, between three and four miles north of the Waitara River. The block extended about fifteen miles along the coast, and contained 60,000 acres. It included the land now the subject of dispute. After the arrival of the settlers, the refugee Ngatiawas and manumitted slaves from Waikato began to return in great numbers, and disputed possession of the block with the settlers. So completely, however, was the Waikato right of conquest admitted, that their permission was sought and obtained by the returning Ngatiawas before they ventured to set foot in the district. The Waikato had, however, previously transferred their rights to the British Government by the deed of cession which will be presently referred to.

In 1844 the Land Claims Commissioner, Mr. Spain, investigated the New Zealand Company's title, and reported in favour of their purchase; but Governor Fitzroy took a different view of the rights of the absent and enslaved Ngatiawa, and refused to confirm Mr. Spain's award.

In consideration of an additional payment, the returned natives consented to surrender a small block of 3,500 acres, comprising the town site; and within these narrow limits the British settlement was for some time confined. Other small blocks were subsequently from time to time acquired, and the settlement now extends for a distance along the coast of about five miles in each direction, north and south, from the town. The European population amounts to upwards of 2,500 souls, greatly outnumbering the resident natives.

The northern boundary of the settlement is little more than four miles from Waitara; but on this side of the town the Crown lands are intermixed with territory over which the native title has not been extinguished. A singular spectacle is here presented of peaceful English homesteads alternating with fortified pas, which command the road to the town at many points, unpleasantly reminding the spectator that the savage law of might still rules in this fair district.

It need scarcely be said that the occupants of these pas do not regard themselves, and practically are not, amenable to British jurisdiction. Since 1854 they have been in continual feud amongst themselves, and there has been a succession of battles and of murders in close proximity to the settled territory. A chief has been slaughtered on the Bell block; skirmishing natives have sought cover behind the hedgerows, and balls fired in an encounter have struck the roof of a settler's house.

These feuds have arisen out of disputes as to the title of land. One native faction has been steadfastly opposed to the alienation of territory to the Crown; the other party has been not less passionately determined to sell, and the contest has been as to their right to do so. The sellers naturally carry with them the sympathy of the colonists, who feel that an extension of the settlement would bring, not simply a material prosperity which this unfortunate place has never known, but also the far greater blessings of peace, security, and the prevalence of British law.

It is obvious that in such a state of things the relations of the two races thus closely intermixed must be full of peril. The embarrassment to the Government is extreme. But without some knowledge of the native character its extent will not be fully apprehended. When a native has offered to cede land to the Crown, his pride (perhaps the strongest passion of a chief) is committed to carry the sale into effect against all opposition, and it may be equally dangerous to the peace of the country to accept or refuse the offer. If the offer be accepted, the Government becomes involved in difficulties with the opposing party; if refused, the seller will seek to revenge himself upon his opponent, or become disaffected towards the Government that has put a slight upon him. If his passion does not turn in either of these directions, he will probably persevere in his attempts to induce the Governor to purchase; thus keeping open a source of agitation and peril. Taranaki is by no means the sole seat of such difficulties. At the present juncture in the affairs of the colony the Government is in other quarters placed in a similar dilemma, and is in the greatest danger of alienating those chiefs who are friendly by the rigid scrutiny to which it is requisite to subject their offers of land. The truest policy would be a fearless administration of justice between the contending parties. Unfortunately to determine absolutely what is just is often impossible in these cases, and were this otherwise the British Government is not in a position to enforce its award.

In March, 1859, the present Governor visited New Plymouth, and on the 8th of that month held a public meeting of all the principal chiefs of the district, the native secretary, Mr. McLean, acting as interpreter. The proceedings had reference to the establishment of British law throughout the Taranaki district, and in the course of his address the Governor said, "he thought the Maories would be wise to sell the land they could not use themselves, as what they retained would then become more valuable than the whole had previously been. He never would consent to buy land without an undisputed title. He would not permit any one to interfere in the sale of land unless he owned part of it; on the other hand, he would buy no man's land without his consent."

Immediately after this declaration by the Governor, a Waitara native, named Teira, stepped forward, and, speaking for himself and a considerable party of natives owning land at Waitara, declared that he was desirous of ceding a block at the mouth of the river on the south bank. He minutely described the boundaries of the block, stating that the claims of himself and his party went beyond those limits, but that he purposely confined his offer to what indisputably belonged to himself and his friends. Being a man of standing, and his offer unexpected by many present, he was listened to with the greatest attention, and concluded by inquiring if the Governor would buy his land. Mr. McLean replied that the Governor accepted the offer conditionally on Teira's making out his title. Te Teira then advanced and laid a native mat at the Governor's feet, thereby symbolically placing his land at his Excellency's disposal. Teira's right was denied by none except a native named Paora, who informed the Governor that Te Teira could not sell without the consent of Weteriki and himself. Teira replied that Weteriki was dying (he is since dead), and that Paora was bound by the act of his relative, Hemi, who concurred in the sale. William King then rose, but before addressing the Governor said to his people:—"I wish only to say a few words, and then we will depart." Then, turning to the Governor, he said: "Listen, Governor! Notwithstanding Teira's offer, I will not permit the sale of Waitara to the Pakeha. Waitara is in my hands. I will not give it up; *e kore, e kore, e kore* (*i.e.* I will not, I will not, I will not). I have spoken;" and thereupon abruptly withdrew with his people.

William King was one of the Nagatiawa who had retired to Cook's Straits, whence he returned to Taranaki in 1848. Though a well-born chief, his land-claims are not considerable, and lie chiefly, if not wholly, to the north of Waitara. On his return to Taranaki, being still in fear of the Waikatos, he applied to Tamati Raru, Teira's father, for permission to build a pa on the south bank, which was granted. He put up his pa accordingly close to one occupied by Teira's party; but his cultivations are on the north side of the river. Rawiri Raupongo, Tamati Raru, Retimana, and the other members of Teira's party, have cultivated the block sold to the Governor; but King has been joined by a number of natives who have gathered about him since his settlement at Waitara, and these men have encroached with their cultivations upon the proper owners. This has been a source of dissension, and one reason determining the sellers to part with their land. King's particular followers, who have been enjoying the use of the land without any claim to share in the proceeds of its sale, naturally support him in his opposition.

W. Kingi's arguments against the sale of the land are stated by the District Land Commissioner in the following terms:—

W. Kingi avowed his determination to oppose the sale, without advancing any reason for so doing. Upon which I put a series of questions to him, which I called upon the Rev. Mr. Whiteley to witness, viz.—

Q. Does the land belong to Teira and party?

A. Yes; the land is theirs, but I will not let them sell it.

Q. Why will you oppose their selling what is their own?

A. Because I do not wish that the land should be disturbed, and, though they have floated it, I will not let it go to sea.

Q. Show me the correctness or justice of your opposition.

A. It is enough; Parris, their bellies are full with the sight of the money you have promised them, but don't give it to them. If you do, I won't let you have the land, but will take it and cultivate it myself.

This petty dispute was the proximate cause of the war. The Governor gave orders that the land purchased from Teira should be surveyed for

sale, and gave instructions to the officer commanding the troops at New Plymouth to protect the surveyors, and to proclaim martial law if he should consider it desirable to do so.

W. Kingi and his followers having forcibly interfered with the survey, Lieut.-Col. Murray made use of the discretionary power entrusted to him, and placed the district under martial law on the 22nd February, 1860. Colonel Gold arrived soon after with reinforcements, and assumed the command. The whole military force at Taranaki, however, at that period amounted to no more than 340 men. With this force Colonel Gold attacked a small pa, which W. Kingi had built within the limits of the disputed land. The pa was abandoned during the night, and destroyed on the following morning.

On the 24th March information was received that the Taranaki tribe, who inhabit the country at the base of Mount Egmont and south of New Plymouth, were about to make an attack upon the town. On the 27th they arrived at Omata, within about 4 miles of New Plymouth, where they erected two pas. On the following day a body of troops marched out by one road and militia and volunteers by another, for the purpose of bringing in some settlers who had remained at Omata, and who were supposed to be in danger. Both bodies were soon engaged, and the militia and volunteers particularly distinguished themselves, and inflicted considerable loss on the enemy. Just before dark Captain Cracroft, of H.M.S. Niger, with a part of his ship's company, made a gallant attack upon one of the pas, of which he obtained possession, almost without resistance, the enemy being taken completely by surprise. On the 29th the Taranakis retired to Warea, about 25 miles south.

In the latter end of April Colonel Gold, having received reinforcements from Auckland, marched to Warea with about 450 men, including artillery and naval brigade. The numerous deep and swampy ravines which intersect the whole face of the country, generally at right angles to the coast line, render the sea-beach itself the only practicable line of march for troops, except in the immediate neighbourhood of New Plymouth, where some of them are rendered passable by means of bridges. This peculiarity, as well as the dense masses of high fern and flax which cover the country outside of the forest, is very favourable to the Maories, who are excellent skirmishers, and know well how to take advantage of the natural features of their country. On this occasion, being either taken by surprise, or not having quite made up their minds what course they should adopt, they offered no resistance, and the troops returned to New Plymouth after destroying several pas.

In the same month a reinforcement of 500 men arrived from Australia, and an entrenched camp was established near the mouth of the river Waitara, and garrisoned by a small detachment.

In June W. Kingi built and occupied a strong pa in a commanding position, about 2,000 yards from the camp, very near the boundary of the disputed land. The communication between this pa and the forest in rear was secured by a chain of smaller pas, all of which were occupied by the enemy.

Some of W. Kingi's followers having assumed the offensive, by firing upon a reconnoitring party, it was decided that an attack should be made

upon the pa. Accordingly, on the 27th June, a force of about 350 men, under the command of Major Nelson, 40th Regiment, marched out of the camp with the intention of surrounding and capturing the pa. With this object Major Nelson divided his force into three detachments, one of which, accompanied by two 24-pounder howitzers, was to attack the pa in front, while the other two were to turn both flanks, and cut off the retreat of the enemy. Unfortunately the force employed was very much too small for the purpose. The howitzers failed to effect a breach in the pa, and the detachments, being too far apart to afford each other support, were unable to reply effectively to the close and destructive fire which was maintained by the enemy's skirmishers in the high fern. The troops were at length compelled to retreat, with the heavy loss of 30 killed and 34 wounded.

At that date the military force at Taranaki amounted to—

Troops and naval brigade	1,188
Militia and volunteers	573
Total	1,761

comprising about 1,500 effectives.

Colonel Gold soon afterwards left the colony, on his promotion to the rank of Major-General. In a speech addressed to the officers of his regiment on parting he used the following words:—

> I need scarcely now inform you that the reasons for my not being allowed to attack William King for a considerable period were political ones; nor need I say that I do not regret having foregone my own aggrandisement and *éclat* as a military officer in the eyes of the world, rather than risk some 2,000 women and children being barbarously murdered by a sudden nocturnal onslaught of the ferocious and bloodthirsty savages, concealed in the closely approximating bush.

I think it is only due to an officer, whose conduct was the object of persistent and unceasing depreciation on the part of the newspaper press of New Zealand and Australia, to say, that, whilst it is more than doubtful whether any effort on his part, with the very limited force at his command, could have done anything material towards reducing the Maories to submission, it is certain that for the thoughtful and provident care with which he watched over the safety of the lives and property of the settlers, he merited from them a measure of gratitude which he was far from receiving.

When the intelligence of the unfortunate attack on Puketakauere reached Melbourne, Major-General Pratt, C.B. commanding H. M. forces in Australia, determined at once to proceed to the seat of war, taking with him every available soldier. The colony of Victoria was, with the consent of its government, entirely denuded of troops, and the other Australian colonies very nearly so. These troops were despatched as rapidly as possible during the month of July to Taranaki, where the General and staff arrived on the 3rd August. The force at the seat of war at that time occupied, besides the town of New Plymouth, four detached posts, two of which were to the north and two to the south of the town. Those on the north comprised an entrenched camp on the left bank of the Waitara, one mile from its mouth and about ten from New Plymouth, and a block-house, commonly known as the Bell-block Stockade, at the village

of Hua, about four miles from the town. There was also a block-house at the mouth of the Waitara, which was garrisoned from the camp.

The posts on the south were the Omata Stockade, about four miles from New Plymouth and a little inland, and an entrenched camp on Waireka Hill, about a mile beyond Omata, and separated from that post by a deep and densely timbered ravine, which rendered a considerable force and extraordinary precautions necessary in escorting provisions and ammunition to the camp.* Within the town itself were two small but strong forts, Marsland Hill and Fort Elliott, and it was partly surrounded by a chain of small block-houses, but was unprovided with a continued enceinte of any kind; and as the forest approaches within a very short distance of it, and many deep and precipitous gullies, the sides and bottoms of which are thickly clothed with fern and scrub, extend from the bush through the line of posts into the town itself, the continued presence there of a large body of troops was indispensably necessary to guard against a night surprise, in which the town would have been burnt and the women and children in all probability murdered.

The total armed force at the disposal of the Major-General at this period amounted to a little over 2,000 rank and file, including the naval brigade and all the men borne on the muster-roll of the volunteers and militia. From these last must be deducted a large proportion necessarily employed in civil capacities, as boatmen, sailors, carters, bakers, butchers, &c. leaving about 2,000 for the whole available force. Of this number little less than one-half were stationed in the various outposts, and so large a proportion of the remainder was, as above explained, compelled to remain in the town, that only about 500 rank and file could be depended upon as available for active military operations at any distance from the town, except immediately in front of the Waitara Camp, where they might have been temporarily reinforced by a part of its garrison. It was found quite impossible to obtain accurate information as to the strength of the Maories actually in arms in the vicinity, but they were generally estimated at from 1,700 to 1,800, of whom it was supposed that about one-half, consisting of the Ngatiawas under Wiremu Kingi, and the Waikatos, had their head quarters in the Waitara district, their most advanced post being Puketakauere; while the remainder, comprising the Taranaki and Ngatiruanui tribes were engaged in an attempt to invest the Waireka camp on the south, by means of long lines of rifle-pits supported by pas. The base of operations of both these parties was the dense and almost impenetrable forest, which, spreading from the slopes of Mount Egmont, covers a great part of the province of Taranaki, and stretches all along the coast line to within a short distance of the sea-shore. For many miles north and south of New Plymouth, this great forest is only separated from the sea by a narrow belt, varying from one-and-a-half to four miles in width, of land either naturally free from timber or artificially cleared. A comparatively small portion even of this contracted space is under cultivation, the rest being generally covered with very thick fern, often from 5 to 10 feet in height, interspersed with brambles. The whole face of the country is intersected by a network of wide, deep, and often precipitous ravines, generally swampy at the bottom, and their

* See Map, Plate I.

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two 8 and two 10-inch mortars which had just arrived from England, were moved to the front and placed in position. At 11 a.m. the enemy's white flag was lowered, and a red one hoisted, upon which firing recommenced on both sides.

On the night of the 16th, a last attempt was made to destroy the head of the sap, which was defeated by the explosion of an 8-inch shell which had been attached to the sap-roller for that purpose.

On the 18th the enemy finally sued for peace, and the war came to an end.

The Waikatos, having agreed to give up the whole of the arms and plunder they had taken, returned to their own country accompanied by Wiremu Kingi, whose immediate followers came in, and made submission.

Mr. RIDGWAY: It was stated by Mr. Buxton in the House of Commons the other night that the war was raging fiercely in New Zealand now. I should like to ask Captain Pasley whether it is in his knowledge that such is the fact?

Captain PASLEY: I do not believe there is any war in New Zealand at present. The Australian mail has just arrived, and there is nothing about it in that; on the contrary, everything appears quite quiet.

Mr. RIDGWAY: I am pretty well up in New Zealand affairs, and I beg to state that the assertions which have been made with reference to the prevalence of war in New Zealand are totally without foundation. General Pratt has accomplished the defeat of the natives. There has been no war in New Zealand since the arrival of General Cameron. If the time would permit, I would have asked some more questions.

Mr. FITZGERALD FOSTER: What is the greatest number of natives that ever met our troops during the recent war?

Captain PASLEY: It is impossible to state exactly. It is supposed that the number of natives engaged in the operations just detailed was about 2,000. It is impossible to say whether the whole of the 2,000 were actually engaged in action on any one occasion.

Mr. FOSTER: Did you ever hear it computed what number of men the natives could bring into the field at once—I do no not mean in the late war, but in future?

Captain PASLEY: It would depend entirely on the union of the tribes, which is a very unlikely thing to take place. In the first place, the Ngapuhi tribe and its chiefs appear to be as firm friends of ours as ever they were, and they constitute one of the most numerous and powerful of the Maori tribes. Taking the population of the northern island south of Auckland, that is, exclusive of the Ngapuhis, it might be about 40,000 altogether, and probably one-third would be adult males.

Mr. RIDGWAY: I can state that the population of adult males in New Zealand is 30,000; including men, women, and children, 56,000. The Europeans were 70,000, and since then the augmentation of the British forces has considerably increased that number.

LECTURE.

Friday, April 11th, 1862.

MAJOR-GENERAL the Hon. JAMES LINDSAY, M.P., in the Chair.

THE WAR IN NEW ZEALAND.

By CAPTAIN C. PASLEY, R.E.

PART II.

IN a paper which I had the honour to read before this Institution a few weeks since, I gave a short account of the history of New Zealand down to the conclusion of the recent war. I propose on the present occasion to offer a few observations on the character of warfare in that country, on the kind of arms that the natives use, with their reasons for adopting them, and on the peculiarities of their defensive works, which, although inapplicable to European warfare, are well deserving of consideration as evincing a natural aptitude for war on the part of the Maories which would be remarkable in any nation, and the existence of which amongst a people so recently rescued from total barbarism is probably unparalleled.

A great deal has been said of the apparent absurdity of a considerable number of troops being kept as it were at bay by a not very numerous body of semi-savages. In a leading article dated the 20th December, 1860, "The Times" contrasts the two pictures of British prowess presented on the one hand by the small allied force (chiefly British) dictating terms of peace to the Chinese Emperor "on the very walls of a capital containing 2,000,000 of inhabitants," and on the other, by "a force of 3,000 effective men commanded by a veteran general, and with an unusually large number of colonels and other officers amply equipped with artillery and with all the munitions of war, drawing its supplies by sea, and backed by a British fleet of six ships of war, which can hardly hold its own against a horde of naked savages never exceeding 600, and now probably reduced to some 120; armed with wretched flint and steel muskets and tomahawks, unprovided with the scantiest apparatus of warfare, and almost destitute of subsistence." The writer goes on to say that a force of 1,000 men under General Pratt "had already declined the siege of a pa of somewhat more than average strength."

As an evidence of the recklessness of assertion which characterised the article in question, I will simply observe, that the number of effective troops (including Naval Brigade) at the disposal of General Pratt at the period referred to was just one-half of the number stated; that, so far from there being "an unusually large number of colonels and other officers," the force laboured under the disadvantage of possessing unusually few officers of all ranks; and finally that the force under General Pratt,

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Fig. 1 shows a view of the outside of the stockade, taken from the foot of the slope on the north side of the building.—The ditch, as shown here, surrounds the stockade, the outer edge or counterscarp being distant on an average about thirty-two feet from the outside of the stockade. Its form is an oblong. A section of it is shown in fig. 3.

Rough wooden steps lead from the drawbridge to the entrance gate. The drawbridge has a span of ten feet, and works upon strong hinges at the end nearest the gateway. It is constructed so as to be as light as possible, consistent with the requisite strength for bearing the ordinary traffic and the provisions, &c. which had to be taken across it. By ropes fastened to its front edge, and running through blocks on the top of the inner posts, it is elevated at night to a perpendicular position, thus serving to prevent ingress or egress. A light moveable handrail on each side (withdrawn at night) prevents accident in crossing the bridge.

It will be seen that the bastions are of two stories each, being loop-holed on all four sides of both stories. The lower part of each is a sleeping apartment. The upper is the post for the sentries at night and in bad weather.

The roof of the bastion is raised clear of the wall-plate, and is made to project a foot, or rather more, beyond the wall of the building. This arrangement admits of the sentries keeping a good look-out all round, yet protects them, to a great extent, from the weather; and further, allows of firing through the space between the roof and the wall-plate, when more convenient to do so (as was often found at long ranges) than through the loopholes. The other parts of the building have a single row of loopholes only. The roof of the sides and ends of the building is made to project about a foot beyond the outside, so as to make it extremely difficult to scale.

The entrance-gate is made of two thicknesses of "heart of pine" timber, each 2½ inches thick, the outer running up and down, the inner diagonally, and strongly nailed together with spike nails, rivetted. It forms a solid door five inches thick. The jambs and sills, of heart of pine, are 12 inches by 9 inches. The jambs are sunk 5 feet into the ground; the whole framed together and well fastened to the building on each side. The hinges form, at the same time, the fastening to the gate; they are stout iron bands, extending across the door, and fitting over a staple with an eye (driven into the door-jamb), and are there secured by dropping an iron pin through the eye.

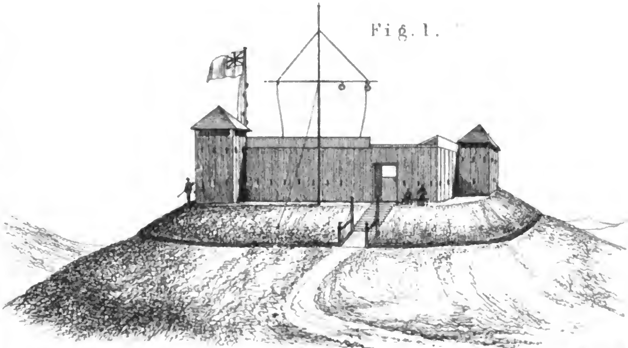
The signal staff is erected outside, but worked from within the building. It is one single young tree 60 feet long, sunk 6 feet in the ground, and properly secured by stays, guys, &c. The yard is 24 feet long. The signal balls are of wicker covered with canvass. There is an easy code for using them.

The small staff is quite unconnected with signals, and is for a British flag.

Fig. 2 shows *Ground-plan.*—The stockade is on the site of an old native war pah, called Nga-ture, or "the knees." The situation being that best fitted of any in the district for a post, it was necessary to adapt the building, both as to dimensions, mode of construction, and other matters, to the local circumstances.

The outer part is constructed either of trunks of small trees entire, or

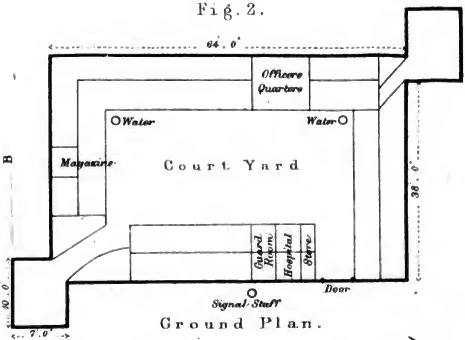
Fig. 1.



J.E.A. From a Sketch by T. Good. Ens. T.M.

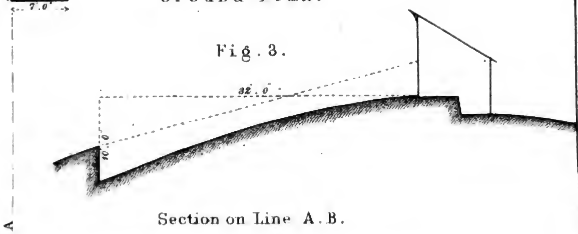
PERSPECTIVE VIEW OF THE OMATA STOCKADE, TARANAKI, N.Z.

Fig. 2.



Ground Plan.

Fig. 3.



Section on Line A.B.

Shewing Slope in front of outside of Stockade.

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V. Colonel SYKES, M.P., F.R.S.—

A Resolution has been put into my hands, to return thanks to the Auditors for their services, and that the following gentlemen be elected for the ensuing year:—

THOMAS SMITH, Esq. (re-elected).	H. F. DOWNES, Esq.
Captain J. E. A. DOLBY.	HENRY ELLIOTT, Esq.

I think the Members of the United Service Institution are very much indebted to any gentlemen who engage themselves in the disagreeable task of verifying figures and facts, and therefore you ought to give them no ordinary thanks for a work of that kind, which is, I think, distasteful to almost everybody.

General EDWARDS—

I beg to second that Resolution.

The Resolution was put and carried unanimously.

VI. Colonel P. J. YORKE, F.R.S.—

The object of the Resolution that I have to propose, is to enable the COUNCIL to carry out the recommendation in the latter part of the seventeenth paragraph of the Report. In the course of last year a very important and valuable present was made to the Institution by Mr. Walter Hawkins, who had been a great collector of coins and medals. He bequeathed the whole of that collection to this Institution. A part of that collection consisted of the electro-type copies of certain gems and coins. The Queen's College, Cork, had previously become possessed of a set of these electrotype copies. That collection was unfortunately lost in a fire, and the College of Cork are now very anxious to obtain possession of our collection of electrotype copies. Of this collection about 600 specimens are copies of gems, and the remainder are copies of Greek and Roman coins. Some of the electrotype copies are from originals, which will still remain in our possession. It has been thought by the COUNCIL that we could very well spare this collection. It is a collection more appropriate to a college than it is to an institution like ours. There is no direct connection between the objects of that collection and the objects that we propose in this Institution. We therefore wish to ask the Meeting to authorise the COUNCIL to dispose of this collection of electrotype copies of gems and coins to the Cork College. We think we shall by that means accommodate a very meritorious and useful college in Ireland, and be doing considerable good to ourselves, by adding the sum we shall acquire from the sale to our own capital. I therefore move this Resolution. "That this Meeting authorise the disposal to the authorities of the Queen's College, Cork, of the collection of the electrotypes of antique coins and gems bequeathed to the Institution by the late Walter Hawkins, Esq., F.S.A.

Lieutenant-General FOX—

I beg leave to second that motion, being a little interested myself in coins. We certainly ought not to think of collecting coins, though what we have got we may very well keep.

Captain A. C. TUPPER.—

I quite agree with Colonel Yorke in all he has said. It is a fact that the collection is of very little use to us.

Commander GARDINER, R.N.—

How will this proceeding be consistent with the donation? Will it be a sale or a gift?

Colonel YORKE.—

It will be a sale. There is no limitation in Mr. Hawkins' bequest to the Institution.

Commander GARDINER, R.N.—

It seems to me a strange thing to take a bequest and then convert it into money.

Colonel YORKE.—

It is a very small part of the bequest we part with. The coins we retain: it is only the copies we propose to dispose of.

The Resolution was then put and carried.

The CHAIRMAN announced that the business of the Meeting was concluded.

Admiral Sir FREDERICK GREY having quitted the Chair, Lieutenant General Fox took the vacant seat and proposed a vote of thanks to Sir FREDERICK GREY.

Captain FISHBOURNE, R.N.—

I have much pleasure in seconding the Resolution which has been proposed by General Fox.

The Resolution was carried with acclamation.

Admiral SIR FREDERICK GREY—

Gentlemen,—I believe it is in accordance with the custom at these meetings that I should address to you a few remarks. When your Chairman came to me and informed me that the Council had selected me to take the chair upon this occasion, I felt very naturally that there were many members of the Institution who would be better qualified to take that duty upon them. But I should be sorry to have had it supposed that I took so little interest in the welfare of this Institution as to refuse a request thus conveyed to me.

Gentlemen,—we meet this year under circumstances very different from those of last year. Last year you, in common with the whole people of this mighty empire, were mourning over the loss of that great, and good, and wise Prince who had not long before been removed from among us. He was always one of the first to promote the interests of science and the welfare of the country. He was a patron of this Institution. His loss we then regretted, and we sympathised with the sorrows of our Queen, upon whom the heaviest blow that can fall upon any loving heart had fallen. We now meet under happier auspices. We have lately joined in welcoming to our shores a Princess descended from the same northern race from whom we have sprung, adorned with all those qualities and charms which are calculated to do honour to the high station in which she was born, and to the still higher station to which she is now called. We have an additional interest in this event, for we all feel that her union with the Prince of Wales is not like many unions which have so often taken place in high places, dictated solely by political motives, but that it is a union of two persons who had met and loved each other, and that the bride whom the Prince of Wales has now brought home is the chosen and selected bride of his own heart. Let us hope, though the blow which has fallen upon our Queen may still press heavily upon her, that she may find some alleviation, in the happiness which she thus sees among her children, and in the new interests which are daily rising about her.

Gentlemen,—during the past year we have had to lament the loss of two distinguished officers who were members of this Institution, two admirals of the fleet, Sir John West and Sir Graham Hamond. They have been taken from us in the fulness of years and honours, but they have left behind them names which are recorded in the pages of our history during that long struggle which ended in 1816.

But to turn more immediately to the Institution itself. After what has been said by Colonel Kennedy and Captain Selwyn, it is unnecessary for me to dwell at any length

upon the present condition of the Institution. It must be clear to every gentleman who has heard this Report read that we are in a state of daily increasing prosperity, that the objects of the Institution are becoming more widely extended, and that the information which this Institution affords is now disseminated to all parts of the world to a much greater degree than has ever hitherto been the case. In looking over the statement of the number of members I think it is satisfactory to observe that the number of members, after fluctuating for some years, has, since the year 1857, steadily increased, and that the increase in the receipts from members during the same period has very nearly doubled.

I believe it has been rightly said that a great deal of this prosperity is owing to the Journal, which furnishes, not only to the Members who are in London, but carries to distant parts of the world, reports of the lectures and the important discussions which take place in this theatre. That Journal has been very much a main element in the increasing prosperity of the Institution. I trust, therefore, that nothing will be done which can in any way militate against the improvement and the extension of the usefulness of the Journal. But, although the Journal itself is most valuable and most useful, I quite agree with the remarks of gentlemen who have preceded me, that it is to the *Lectures* and the *Discussions* that most importance should be attached.

I think that the want of some arena in which professional questions can be calmly and dispassionately discussed is most strongly felt, particularly since the commencement of the present Session of Parliament. I think no person present who has heard or read the debates which have taken place in the House of Commons during the present Session can have failed to be struck with the unfitness of such an assembly for discussing professional questions. In fact, when we consider what the composition of that assembly is, it is not to be wondered at, because I believe there are very few members in that House who possess really the scientific knowledge connected with professional matters to enable them to enlighten the public upon them. Some of the gross mistakes which have been made must, I think, have struck everybody here. I may go further, and say, not only is it in the House of Commons that we see this, but no later than this very morning I read in the "Times" newspaper a leading article, written, I suppose, by some person presumed to be competent to judge of these matters. He has written an article upon the much-disputed question of iron and wood ships, in connection with the debate which has taken place in the House of Commons. In the commencement of that article the writer argues that the Admiralty are going to build certain wooden ships for the purpose of converting them afterwards into armour-plated ships. I can only suppose that the gentleman who wrote that article was ignorant of the meaning of the professional term, "converting timbers." When he heard that the Admiralty were going to "convert timbers" for building five wooden ships to be plated with iron, he believes, first, that those timbers are to be framed in some way, and then to be altered in some other form for the purpose of being afterwards plated. That struck me so strongly this morning that I could not help alluding to it as an instance of the disadvantage which may arise in assemblies where there are no persons able and competent to explain the meaning of the technical terms used.

We must all remember the interesting discussion that took place last year in this theatre. I need only allude to that interesting discussion which occupied two nights on the question of rifled ordnance. I think no gentleman who attended those discussions could have gone away without having gained most important information, and have learned facts which he did not know before. I am sure of that; and not only so, but that the different members of the Government, and the heads of the departments who are engaged in carrying out those important improvements which the advances of science render necessary, must have acquired a great deal of information upon that occasion. And not only upon that subject, but upon all professional subjects, we derive advantage from these Lectures and Discussions. I do hope and trust that the course which the Council have so wisely adopted in this respect may be continued.

Gentlemen,—I have to thank you for having listened to me so long. I will not detain you longer. I will only congratulate you most sincerely upon the very favourable position in which the Institution now stands.

STATEMENT OF CHANGES AMONG THE MEMBERS SINCE 1ST JANUARY, 1862:—

	Life.		Annual.		Total.
Number of Members on 1st January, 1862 .	833	+	2856	=	3689
Do. who have joined during 1862 .	18		224		242
	851		3080		3931
Changed from Annual to Life . . .	+ 5		—5		
	856		3075		3931

	Life.	Annual.
Deduct—Deaths during 1862 . .	14	70
Withdrawals . . .		26
Struck off . . .		24

	Life.	Annual.	Total.
Deductions	14	120	134
Number of Members on 1st January, 1863 .	842	2955	3797

TABULAR ANALYSIS OF THE STATE OF THE INSTITUTION,
To the 31st of December, 1862.

Year. 1st Jan. to 31st Dec.	Annual Subs. received.	Entrance Fees.	Income (from all sources).*	Life Subs. received.	Amount of Stock.	Invested in the purchase of Books, &c.	No. of Vols. in Library.	No. of Members on the 31st Dec.	Number of Visitors.
	£	£	£	£	£	£			
1831	654	..	654	1,194	..	..	..	1,437	..
1832	1,146	..	1,146	973	..	..	..	2,699	..
1833	1,405	..	1,450	692	..	..	..	3,341	..
1834	1,500	..	1,549	583	1,100	..	..	3,748	13,376
1835	1,480	..	1,574	366	2,430	40	..	4,155	8,537
1836	1,570	..	1,682	330	3,747	45	..	4,069	8,521
1837	1,549	..	1,747	222	4,747	180	..	4,164	10,907
1838	1,462	..	1,634	230	5,500	246	..	4,175	15,788
1839	1,399	..	1,565	168	5,500	292	..	4,186	16,248
1840	1,363	..	1,525	198	5,500	446	5,500	4,257	17,120
1841	1,450	..	1,643	186	6,000	243	5,850	4,243	19,421
1842	1,373	..	1,565	144	6,400	373	6,450	4,127	21,552
1843	1,299	..	1,494	140	6,700	237	7,000	4,078	27,056
1844	1,274	..	1,408	112	3,000	298	7,850	3,968	22,767
1845	1,313	..	1,466	228	1,500	127	8,100	3,988	21,627
1846	1,298	..	1,456	138	1,500	74	8,410	4,031	32,885
1847	1,314	74	1,502	132	1,700	37	..	4,017	38,699
1848	1,175	57	1,375	48	1,700	85	9,641	3,947	37,140
1849	1,176	72	1,375	84	1,150	58	..	3,970	33,333
1850	1,141	106	1,294	198	600	36	..	3,998	33,773
1851	1,136	131	1,292	66	666	34	10,150	3,188	52,173
1852	1,134	133	1,281	114	200	43	10,300	3,078	20,609
1853	1,243	319	1,684	264	528	41	10,420	3,251	25,952
1854	1,200	138	1,368	126	612	95	10,587	3,171	22,661
1855	1,159	107	1,289	120	653	55	10,780	3,131	14,778
1856	1,216	197	1,519	156	761	47	10,832	3,204	16,184
1857	1,258	176	1,937	78	1,038	40	10,960	3,168	12,755
1858	1,318	221	2,102	105	438	31	11,062	3,246	25,747
1859	1,526	195	2,277	512	946	70	11,320	3,344	28,739
1860	1,961	298	3,577	397	2,178	114	11,517	3,518	28,011
1861	2,122	305	2,899	266	2,846	99	11,812	3,689	23,296
1862	2,296	242	3,127	239	3,178	109	12,026	3,797	27,215

* Including Annual Subscriptions, Entrance Fees, Donations, Legacies, and Interest on Funded Property; and also the grant from Government, commencing in 1857.

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WHO JOINED THE INSTITUTION BETWEEN THE 6TH MAY AND 31ST DECEMBER, 1862

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Papers relating to the Mission of the Right Hon. W. E. Gladstone to the Ionian Islands in the Year 1858.

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Report of the Progress of the Ordnance, Survey, and Topographical Depôt, 31 Dec. 1861.

Report to the Board of Trade, containing an Abstract of the Returns of Wrecks and Casualties on or near the Coast of the United Kingdom from 1st January to 31st Dec. 1855, 56, 57, 58, and 59.

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Return of the Militia in each County, 1861.

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Volunteer Force, Australia.

Exploration British North America.

Papers relating to the Exploration by Captain Pallisser, of that portion of British North America which lies between the northern branch of the river Saskatchewan, and the frontier of the United States, and between the Red River and the Rocky Mountains, 1859.

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COLBURN'S NEW MONTHLY MAGAZINE. 3 Nos. Containing an Account of the Ascent of Mont Blanc by a Private of the 38th Middlesex. (Artists) *John Barrow, Esq., F.R.S.*

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1st January, 1754.
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ROYAL ENGINEERS ESTABLISHMENT PAPERS, *continued.*

Paper 18. On the Resistance of Fluids to Bodies in Motion, by Lieut. H. W. Clarke, R.E., March 7th, 1862.

Lecture 1. On Telegraphy for Army and Navy Purposes, by Capt. F. J. Bolton, 12th Reg. April 8th, 1862.

Lecture 2. On Hydraulic Engineering, by S. U. Roberts, C.E. May 13th, 1862.

Paper 1. Report on the Inundation at the Middle Level Sluice, Norfolk, 1862.

Paper 2. Letter from Col. Sir William Denison, K.C.B., R.E., on the Influence of Rifled Cannon and Small Arms on the Attack and Defence. Read Oct. 3rd, 1862.

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